A QUANTITATIVE AND QUALITATIVE ANALYSIS OF SWINE FINISHING HOUSE DUST WITH SCANNING ELECTRON AND LIGHT MICROSCOPY

by

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B.S., University of Wisconsin at River Falls, 1983

A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

AGRICULTURAL MECHANIZATION

Department of Agricultural Engineering

Kansas State University
Manhattan, Kansas

1987

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Introduction

Dust control in the livestock building environment is a problem that has grown with increased use of confinement housing. High concentrations of dust levels are found in enclosed buildings with large animal populations. The large quantities of dust are difficult to remove with standard ventilation systems (Gast and Bundy, 1986). Dust in hog barns is a serious nuisance for several reasons: 1) dust acts as a vehicle for animal disease organisms, 2) dust inhalation over time could result in fibrosis of animal and human lung tissues, and 3) dust fouls equipment, thus reducing efficiency and durability (Phillips, 1986).

A variety of respiratory conditions have been recognized in people who work in swine confinement buildings (Donham et al. 1977). These conditions include bronchitis, reversible airways obstruction and symptoms similar to either hypersensitivity pneumonitis or organic dust toxic syndrome (Donham and Gustafson, 1982; Donham et al. 1986). Human health problems most likely are the result of the combined effects of inhaled dusts and gases (Donham et al. 1977; Donham and Gustafson, 1982). The health hazard of dust is dependent on the following characteristics: 1) Number of particles which are small enough to be drawn into the alveoli region of the lung and which are referred to as the respirable fraction, 2) high concentrations of protein, 3) high count of bacteria and fungi, 4) activity of endotoxin, and 5) absorption of irritating gases (Donham and Leininger, 1984).

The majority of the aerial and settled dust particles in swine finishing confinement buildings originates from feed (Chiba et al. 1986; Curtis et al. 1975; Donham et al. 1986; Honey and McQuitty, 1979; and Havmond and Slot, 1968). However, dust in nursery and farrowing buildings is comprised largely of fecal particles (Donham et al. 1986). According to Bundy and Hazen (1975), concentrations dust were influenced by methods of feeding and type of feed. Similarly, Chiba et al. (1986), and Gore et al. (1986), found that the addition of 5% dietary fat or soybean oil reduced concentrations of aerial dust by greater than 40% in finishing and nursery buildings, respectively. Therefore, control of dust emissions from feed would probably result in a more productive and healthy environment (Gast and Bundy, 1986).

Though evidence is mounting that airborne swine house particulates are comprised mostly of feed, much is left to be understood. Factors such as origin, size distribution, morphology, and seasonal fluctuations of dust concentrations are important to the Agricultural Engineering Technologists and Agricultural Engineers when considering methods of control and removal of swine house dust. Therefore, the objectives of this research were to: 1) determine origin, size, and shape of airborne particles in swine finishing units, and 2) analyze the differences between farms and between farm visits.

Review of Literature

The Problem

Except for young livestock, producers use enclosed animal houses for labor-saving conveniences - not for animal shelter per se. Only with the trend to confinement has air environment became a potentially critical element in livestock production. In addition to normal atmospheric components, air in animal quarters contains exotic trace substances and excess amounts of natural components. These components may be gases, liquid droplets or solid particles; organic or inorganic; viable or nonviable; noxious, pathogenic or inert; and there are several feasible permutations (Curtis, 1972).

The quality of the air in total confinement swine buildings can be lowered by the presence of atmospheric contaminants such as gases and dust (Honey and McQuitty, 1979). A well recognized problem associated with atmospheric swine dust is the contribution of dust to the rapid deterioration of buildings and equipment. More recently, attention has been focused on evaluating its potential hazard to the animals and to the human workers.

Human Health Aspects

Numerous respiratory diseases of man and some common respiratory diseases of domestic animals have been associated with the inhalation of dusts of animal or vegetable origin. Chronic exposure to dust will

often lead to irreversible lung damage (Martin and Willoughby, 1972). A variety of respiratory conditions have been recognized in people who work in swine confinement buildings (Donham et al. 1977; Baxter, 1969). The potential hazard of airborne particles is dependent upon quantity, size and composition (Bundy and Hazen, 1975). Asthma, urticaria and hayfever may result, where particle sizes are large enough to confine entry to the nose and upper respiratory passages, but acute and chronic bronchitis, chronic emphysema, bronchial pneumonia and fibroid lung may occur when particle size is small enough to penetrate to the alveoli (Baxter, 1969). Anderson (1958) found that particles smaller than 5.2 microns would penetrate to the aveolar regions of the lung. Ninety-five percent of the dust in swine buildings is in the particle sizes considered to be damaging to the lungs of animals and humans (Bundy and Hazen, 1975). In a atudy of swine confinement operations sampled in winter months, Donham et al. (1986) found that the measured concentration of total aerosols exceeded the Threshold Limit Value, TLV, (TLV is a time-weighted average air concentration believed to cause no adverse effects in most workers repeatedly exposed during the usual eight hour workday, five days a week, NIOSH (1986)) for total nuisance dust, but not for respirable nuisance dust in half of the finishing buildings. Aerosol limits for nuisance dust, however, probably are not adequate for swine dust since it contains foreign protein, grain dust, insects and insect parts, fecal material, bacteria, mold spores, and possibly other biologically active substances. The presence of adsorbed ammonia complicates assessment of the potential health hazards of this dust.

Studies cited by Donham et al. (1986) have noted that the combination of inhaled dusts and gases may affect human health.

Swine Health Factors

Animal environment has developed as an integral part of total animal management systems. Livestock exposed to adverse environments experience reductions in rate and efficiency of performance. Concerns regarding environmental pollution and labor-saving devices including mechanization and improved livestock handling facilities have placed animals in environments that impose a wide variety of alterations which have resulted in changes in the physiological, sociological, behavioral and psychological responsiveness of the animal (Ames and Ray, 1983).

Workers confront industrial environments for relatively short intermittent periods, whereas confined animals confront their environments almost continuously. Livestock also face many potentially harmful air factors simultaneously. Air pollutants of most importance to animal production differ from those of concern to human health. Pollutants of industrial origin concern public health workers. Most air factors of concern to animal production result from normal animal functions, production practices, or both. Thus many air factors originate from the animals as well as affect animals. Enclosure lessens atmospheric dilution of these air factors, especially when other considerations dictate low ventilation rates (Curtis et al. 1972). The practice of collecting swine waste under partially or totally slotted floors has added to the air quality concern, since

waste may be held in the building long enough for bacterial action to produce gases (Day et al. 1965). Sutton et al. (1986) also found gaseous pollutants, odors, dust and bacteria to be found commonly in enclosed swine units. They resulted from decomposition of excreta animal respiration by animals, operation of fuel-burning heaters, and feed delivery systems. The quality of the air within total confinement pig buildings can be lowered by the presence of these atmospheric contaminants (Honey and McQuitty, 1979).

Although there is little evidence to suggest that dust content of dust in a livestock environment will have a detrimental effect on the growth rate or food conversion of livestock, it may, through its irritating action on the respiratory passages, predispose the animal to other respiratory infections (Baxter, 1969). The conclusion that raising swine in dusty air may predispose the animals to respiratory diseases is also supported by Donham and Gustafson (1982), Jericho (1968), and Martin and Willoughby (1972). Insidious respiratory disorders are among today's most economically important swine diseases. Chronic pneumonia is widespread and it may alone reduce growth rate by up to 30 percent (Huhn, 1970). Dust accumulation in swine buildings can be a contributing factor in intensifying pneumonia (Switzer et al., 1981). Even moderately low concentrations of gases, dust and bacteria in swine units can stress pigs by irritating tissues in the respiratory tract, increasing susceptibility to diseases and reducing overall performance (Sutton et al., 1986). Exposure of corn starch and SO_2 resulted in a loss of cilia from the epithelium of larger bronchi, although exposure to either of these two agents alone failed to produce

this change (Martin and Willoughby, 1972). Therefore, the interaction of air factors found in swine confinement houses may influence the incidence and severity of chronic pneumonia in swine (Jericho, 1968; Kovacs et al. 1967). However, Curtis et at. (1975) found that the rate of gain and structure of the respiratory tract of growing pigs, which were free of respiratory disease, was not directly influenced by NH_3, H_2S, dust and combinations at levels commonly encountered inside enclosed houses at commercial swine production operations. More recently, dust has been reduced by over 40 percent when tallow or soybean oil was added to the feed (Chiba et al. 1986, and Gore et al., 1986). In Chiba's study, the overall incidence of lung lesions was higher in pigs fed the diet without tallow. Also, there was a tendency for pigs fed the diet without tallow (higher concentration of dust) to have more severe forms of lung lesions than those fed the diet with tallow. The pigs fed the diets containing tallow or soybean oil also consumed less feed and had improved feed conversion. These results agree with reports by Nordstrom et al. (1972), Leibbrandt et al. (1975), Seerley et al. (1978) and Keaschall et al. (1983).

Characteristics of Swine Dust

A large quantity of dust is produced when swine are confined (Bundy and Hazen 1975) and production of dust varies with the season (Stroik and Heber, 1986). Concentrations are lowest during summer when ventilation rates are highest (Phillips, 1986). Also, pigs tend to become less active with increasing temperature. Diminished animal

activity is assumed to yield less dust (Honey and McQuitty, 1979).

Dust usually has the same chemical composition as the substances from which it was derived and its particle size will determine the degree and duration of its suspension in air. Dusts in livestock accommodations may be of an organic or inorganic nature and arise from the feeding of dry friable products, the attrition of building materials, the drying and fragmentation of waste products and the removal of hair and skin tissues, etc., from the animals (Baxter, 1969).

Qualitative microscopic analysis of swine confinement aerosols revealed that they were heterogeneous in nature with a great diversity of shape and composition. Some of the components identified included the following: feed, fecal material, swine dander, mold, pollen, grains, insect parts, and mineral ash. The bulk of the collected particles was made up of feed and fecal material (Donham et al. 1986). The conclusion that swine house dust was mostly feed dust is similar to the findings of Chiba et al. (1986), Curtis et al. (1975), Honey and McQuitty (1979), and Hovmand and Slot (1968). The dust generated during delivery of feed to the feeders is a major source of the total amount of airborne feed dust (Chiba et al. 1986).

Photomicrographic analysis of swine airborne dust resulted in the finding that about 1 percent of the particles in the 11 to 16 micron size range were pieces of hair. Ten percent of the total particles and; about 5 percent of the particles in the 7 to 9 micron size range appeared to have originated from akin. Shape and color were the basis for these observations. Dark fibrous particles were assumed to be

hair, while thin, flat, translucent or white particles were assumed to be skin. The remaining cubical or spherical particles were assumed to have originated from feed (Honey and McQuitty, 1979).

Materials and Methods

Sample Collection

Samples of aerial dust and other pertinent data were collected from 11 commercial swine finishing units. The selection of the 11 commercial farms was accomplished by obtaining a list of swine producers from local veterinarians. The producers were then contacted to obtain information about their finishing units. This information included building type (power vs. natural ventilation, gable vs. monoslope), size, orientation, animal density, waste removal system, and use or non-use of sprinkler systems. Farms were selected to include a variety of building and waste removal types. At least two of each building type (see Table 1) were selected. A complete description of each unit is included in Appendix A.

The sampling was conducted over an eight-month period from July, 1985 to February, 1986, Table 2. Each farm was sampled approximately once a month. Dust particles were collected on a 37-mm membrane filter mounted in an open face cassette filter holder. Air was drawn through the filter with a Sierra-Misco Model 3000 constant flow air sampler. The flow rate ranged from 36 to 72 liters per minute. The sampler was placed in the alley in a central location in the building. The cassette was positioned at a height of 1.5 m. The length of the sampling time varied from 30 seconds to 5 minutes depending on the dust concentration.

Sample Analysis

Both light microscopy (LM) and scanning electron microscopy (SEM) were utilized to evaluate the swine dust particles. The LM was

Table 1. Building parameters of the commercial swine finishing units.

Farm	Building Type	Orientation	Building Size	Gable or Monoslope	Alley Location	Waste Removal
A[1]	EC[2]	E-W	180'x33'	G	Center	Full Pit
B	EC	N-S	320'x33'	G	Center	Full Pit
C[1]	MOF[3]	E-W	200'x28'	G	North	Partial Pit
D[1]	MOF	E-W	100'x36'	M	South	Partial Pit
E[1]	MOF	E-W	96'x30'	G	South	Partial Pit
F	MOF	E-W	150'x28'	M	North	Flush Gutter
G	MOF	E-W	100'x30'	M	South	Partial Pit
H	MOF	E-W	164'x28'	M	North	Flush Gutter
I	EC	N-S	41'x24'	G	None	Full Pit
J	MOF	E-W	180'x36'	M	North	Partial Pit
K	EC	N-S	180'x33'	G	Center	Partial Pit (2)

[1]Sprinkler system

[2]Environmentally controlled

[3]Modified-open-front

Table 2. Other Pertinent Data Collected During Farm Visits.

f	t	day J	time	To C	RHo %	Vo m/s	Dir deg	Ho mg	Ti C	RHi %	Vh m/s	Vl m/s	Mg mg	Mn mg	CO2 ppm	#/lit	Mod ue	BP %
6	P	186	1415	30.3	62.3	6.4	240	.00	31.7	42.2	.	.	2.83	2.83	.	.	.	.
6	P	239	1000	22.2	69.2	2.6	141	.16	25.6	71.0	.10	.10	2.39	2.23	1000	1178	2.8	84.5
6	P	267	1000	10.6	74.8	1.3	99	.07	20.1	71.5	.19	.02	5.46	5.38	500	4044	2.5	90.7
A	P	295	930	18.9	75.6	5.2	181	.08	24.0	74.3	.07	.04	4.16	4.08	800	.	.	.
A	P	322	1445	16.7	74.1	4.1	288	.06	26.3	70.0	.04	.03	8.21	8.14	200	3123	2.1	93.9
A	P	346	950	-7.2	78.5	2.3	238	.06	17.6	51.4	.00	.00	16.12	16.06	250	.	.	.
6	P	21	1000	5.3	62.0	5.0	297	1.93	19.6	64.8	.00	.00	7.41	5.47	150	5970	2.1	95.1
A	P	38	1400	-3.3	87.0	3.9	124	.67	20.3	68.8	.00	.00	12.87	12.20	417	8570	2.1	95.3
8	P	206	1000	23.9	86.7	4.5	233	.24	26.7	70.2	.07	.07	3.39	3.15	1000	4651	2.0	97.6
8	P	241	1040	27.8	58.8	4.0	7	.33	28.3	69.9	.00	.00	3.56	3.23	.	.	.	.
8	P	269	930	6.4	88.8	1.8	252	.01	18.8	69.8	.02	.02	5.25	5.24	650	4091	2.1	94.2
8	P	302	1515	16.1	54.4	4.6	40	.16	21.7	60.1	.00	.02	4.58	4.42	150	2183	2.2	94.1
8	P	323	930	-1.7	73.0	6.5	122	.08	14.5	77.9	.03	.00	9.04	8.96	350	.	.	.
8	P	355	1000	-.6	71.3	2.7	234	.02	16.3	68.1	.02	.00	7.13	7.10	1800	2379	2.1	94.4
8	P	23	1000	3.1	62.3	2.8	182	.39	16.0	60.9	.00	.00	7.69	7.31	2000	5050	2.1	94.6
8	P	58	1600	5.0	61.5	7.8	65	.16	19.4	68.1	.00	.00	8.66	8.49	270	4896	2.3	91.2
C	N	196	1415	27.8	60.0	3.6	95	.33	29.4	60.1	.10	.10	2.67	2.34	500	.	.	.
C	N	232	1015	19.7	80.7	4.4	146	.05	20.6	83.4	.16	.16	4.59	4.53	500	1837	2.2	95.3
C	N	269	1615	16.7	37.6	2.4	285	.17	22.6	51.1	.14	.05	9.94	9.77	800	456	2.3	93.5
C	N	290	1615	22.8	77.8	3.3	189	.12	24.4	66.8	3.65	2.20	4.35	4.23	800	720	2.1	93.7
C	N	316	950	8.9	93.1	1.2	76	.16	18.1	75.1	.00	.05	5.25	5.09	500	2293	2.1	93.3
C	N	13	1320	6.7	30.8	4.0	209	.37	13.1	42.5	.15	.16	25.87	25.49	500	11033	2.1	95.1
C	N	35	1120	3.9	83.5	3.9	196	.64	13.3	71.4	.00	.00	38.16	37.53	750	30632	2.1	94.4
C	N	63	1145	10.0	44.6	2.5	245	.25	17.4	57.7	.00	.00	27.17	26.92	170	26579	2.1	94.2
O	N	294	1315	32.2	62.0	4.5	147	.12	32.5	60.7	1.10	1.10	1.73	1.61	500	322	2.1	96.6
O	N	232	1310	22.8	77.8	3.0	153	.05	22.8	75.7	.23	.23	1.61	1.56	500	1321	2.3	94.5
D	N	274	1530	16.1	40.9	3.3	220	.09	16.5	37.3	.79	.49	4.74	4.65	250	1473	2.4	91.5
D	N	295	1510	24.2	59.1	8.0	186	.06	24.0	58.1	1.88	1.18	5.28	5.22	500	1546	2.2	95.6
D	N	318	1010	1.1	100.0	4.1	42	.15	6.4	77.7	.06	.00	19.27	19.12	100	13560	2.0	94.6
D	N	344	1030	.0	79.8	6.5	28	.17	20.3	78.7	.00	.00	25.68	25.51	350	.	.	.
D	N	16	1615	10.6	62.8	2.2	279	.17	19.3	59.6	.00	.00	5.60	5.43	750	2034	2.1	94.6
D	N	41	1630	-3.9	55.0	2.7	66	.26	12.5	41.6	.05	.00	27.15	26.89	330	27844	2.2	93.9
E	N	229	1430	31.9	60.3	3.5	180	.17	31.1	64.4	.18	.18	.51	.34	.	378	2.1	96.6
E	N	260	1500	33.3	54.0	7.0	204	.37	32.8	57.9	.77	.30	.36	.00	500	349	2.2	95.5
E	N	297	1400	23.9	28.5	2.4	73	.70	26.8	42.4	.12	.06	2.58	1.89	200	877	2.1	93.1
E	N	318	1540	1.1	95.0	4.4	56	.20	15.2	82.2	.00	.00	4.84	4.64	100	1546	2.2	95.6
E	N	14	1520	10.3	42.3	1.6	106	.21	20.7	53.0	.00	.00	1.56	1.35	300	5939	2.1	95.2
E	N	55	1410	12.2	43.4	3.4	185	.48	18.1	55.6	.15	.00	10.14	9.66	500	10778	2.1	95.5
E	N	77	1510	8.3	97.0	5.3	306	.04	11.1	100.0	.00	.00	6.18	6.14	400	2018	2.5	90.1
E	N	91	1015	16.7	41.9	6.2	40	.45	22.3	50.4	.00	.02	1.50	1.05	66	2457	2.5	90.3
F	N	205	1440	31.9	51.5	2.9	117	.09	31.0	62.6	.18	.18	1.01	.93	500	241	2.3	95.8
F	N	239	1530	29.4	47.7	3.5	164	.12	30.0	52.7	.11	.11	.55	.43	500	267	2.1	95.5
P	N	271	1000	9.4	76.9	2.7	50	.49	17.6	84.5	.00	.00	5.74	5.24	1200	805	2.5	90.6
P	N	292	1040	10.6	95.0	3.4	178	.24	17.0	81.1	.00	.00	4.43	4.19	500	571	2.3	91.8
P	N	320	1015	2.8	82.7	3.2	285	.11	22.1	82.8	.00	.00	7.92	7.81	500	2468	2.3	93.3
P	N	348	930	-10.6	71.0	1.7	211	.34	9.4	70.6	.00	.00	8.70	8.37	400	7796	2.0	95.5
P	N	21	1510	5.0	39.9	6.8	300	3.64	15.8	56.3	.00	.02	12.35	8.71	167	3174	2.4	91.2
P	N	42	1145	-6.1	67.0	1.4	195	.38	13.3	61.6	.00	.00	26.27	25.89	150	36722	2.0	94.2
G	N	212	950	23.6	93.2	3.4	36	.28	24.3	92.2	.15	.15	2.09	1.81	.	855	2.4	91.5
C	N	243	1150	33.3	40.7	4.0	224	.24	31.7	45.6	.28	.28	4.44	4.20	750	106	1.9	95.6
C	N	271	1150	10.6	77.8	2.6	34	.24	16.3	72.7	1.05	.85	2.64	2.41	500	1250	2.6	90.9
G	N	292	1220	12.9	87.5	3.0	110	.37	20.1	86.1	.02	.11	1.78	1.41	600	2800	2.4	91.1
G	N	320	1215	7.2	75.7	3.4	272	.24	19.4	58.4	.00	.01	10.76	10.51	200	10615	2.1	93.4
G	N	348	1310	.8	70.0	5.2	226	.03	19.0	67.7	.00	.00	11.31	11.27	1700	8084	2.1	92.7
C	N	21	1300	7.2	38.6	5.7	279	1.28	15.8	38.2	.02	.02	10.45	9.17	1100	5073	2.4	88.1
C	N	42	1530	-6.1	62.2	4.4	245	.49	15.3	60.4	.00	.00	12.67	12.18	700	16651	2.1	94.0
H	N	212	1430	27.8	69.1	3.6	82	.05	27.9	76.0	.08	.08	.39	.34	500	210	2.2	96.4
H	N	234	1330	27.8	83.9	2.8	92	.06	26.9	82.6	.13	.13	.52	.47	500	.	.	.
H	N	262	1545	29.4	60.1	6.0	198	.05	28.9	62.9	1.50	1.13	.94	.89	1000	460	2.2	95.6
H	N	288	1510	23.9	44.7	3.9	273	.22	25.4	44.1	.14	.19	2.01	1.79	500	200	2.8	83.0
H	N	316	1510	7.2	90.0	2.6	49	.07	12.8	85.2	.13	.13	6.85	6.78	600	.	.	.
H	N	14	930	1.1	72.3	3.0	328	.09	15.7	61.9	.00	.00	16.03	15.93	600	7097	2.1	93.7
H	N	35	1400	2.8	85.0	2.5	315	.29	10.6	86.7	.00	.05	10.66	10.37	300	3264	2.3	90.9
H	N	63	1420	16.7	33.4	2.5	273	.26	21.1	44.6	.00	.00	5.07	4.82	330	4464	2.2	95.0
I	P	210	1620	25.6	65.8	3.2	144	.37	28.9	62.9	.	.	3.84	3.47	500	.	.	.
I	P	274	1040	7.2	78.5	2.9	228	.04	25.4	70.3	.00	.00	9.86	9.83	500	2231	2.5	91.0
I	P	294	1600	21.7	56.7	3.6	181	.13	25.3	56.6	.08	.06	3.76	3.63	1000	1011	2.2	92.8
I	P	317	1615	5.0	95.0	4.2	264	.06	23.9	62.7	.00	.00	15.12	15.06	1500	11968	2.0	95.3
I	P	355	1530	6.6	68.7	2.8	225	.05	26.3	66.3	.00	.00	20.58	20.53	2200	14082	2.1	94.1
I	P	24	1530	14.4	33.3	5.9	316	.44	21.8	46.3	.00	.00	10.58	10.14	1400	7137	2.0	94.5
I	P	56	1030	10.0	62.1	1.2	172	.12	21.1	64.2	.00	.00	12.21	12.10	300	9101	2.0	94.4
I	P	77	1230	10.0	86.9	5.2	242	.05	22.2	57.3	.00	.00	7.92	7.87	300	1207	2.4	91.5

Table 2 continued.

f	t	day J	time	To C	RHo %	Vo m/s	Dir deg	Mo mg	Ti C	RHi %	Vh m/s	Vi m/s	Mg mg	Mn mg	CO2 ppm	#/lit	Med um	RF %
J	N	243	1440	33.3	40.7	4.6	215	.16	38.1	26.8	.33	.33	2.03	1.87	.	512	2.3	93.8
J	N	271	1450	7.2	92.7	5.8	76	.00	16.5	69.2	.12	.01	2.28	2.28	200	1143	2.5	91.4
J	N	292	1510	14.4	82.0	2.2	100	.04	20.3	80.2	.11	.03	2.81	2.76	700	4493	2.3	94.7
J	N	320	1530	11.3	62.0	2.8	235	2.52	18.6	77.8	.00	.00	26.21	23.70	500	10303	2.1	93.5
J	S	14	1200	6.1	22.8	3.4	60	.07	17.2	45.4	.00	.05	23.49	23.42	200	14083	2.1	94.1
J	N	42	1350	-3.3	63.0	4.8	190	.30	21.9	59.1	.00	.00	14.20	13.90	4000	9906	2.0	95.0
J	N	64	1550	10.6	45.7	8.9	289	.18	18.3	40.4	.50	.28	12.84	12.66	433	3696	2.3	91.0
J	S	78	1500	7.2	58.0	7.0	210	.04	23.3	64.1	.00	.00	8.74	8.70	225	9692	2.4	90.9
K	P	246	1630	33.9	49.0	4.1	171	.24	33.2	56.8	.06	.06	.62	.38	500	1547	2.4	90.9
K	P	267	1500	17.2	55.8	1.9	99		19.9	58.6	.14	.12	1.18	1.18	100	.	.	.
K	P	294	1400	22.2	53.5	3.6	181	.07	24.9	60.2	.04	.03	1.57	1.50	600	679	2.4	90.5
K	P	317	1450	7.6	90.0	4.5	329	.23	17.6	79.6	.00	.00	3.95	3.72	250	.	.	.
K	P	355	1330	4.6	82.0	3.1	217	.16	17.9	64.8	.00	.00	7.44	7.28	200	2940	1.9	94.5
K	P	24	1410	14.2	37.3	5.8	303	.38	17.2	58.5	.00	.00	4.36	3.99	500	3483	2.1	94.6
K	P	56	920	5.0	76.5	.8	155	.10	18.1	71.5	.00	.00	5.38	5.29	1350	34	2.3	90.5
K	P	77	1100	15.6	73.3	5.0	225	.16	19.7	82.9	.05	.00	3.49	3.33	308	13	2.4	92.9
Surv		199	1302	12.9	65.9	3.9	180	.30	21.2	64.1	.18	.13	8.13	7.84	614	5511	2.2	93.3
A	P	214	1143	11.7	72.9	3.8	201	.38	23.1	64.3	.06	.03	7.43	7.05	474	4577	2.3	91.9
B	P	222	1127	10.0	69.8	4.3	142	.17	20.2	68.1	.02	.01	6.16	5.99	889	3875	2.1	94.4
C	N	177	1274	14.5	63.5	3.2	180	.26	19.9	63.5	.53	.34	14.75	14.49	565	10507	2.1	94.2
D	N	227	1369	12.9	67.2	4.3	140	.13	19.3	61.2	.51	.37	11.38	11.25	410	6871	2.2	94.5
E	N	168	1416	17.2	57.8	4.2	144	.33	22.3	63.2	.15	.07	3.46	3.13	295	3043	2.2	94.0
F	N	217	1201	9.1	66.5	3.2	188	.68	19.5	69.0	.04	.04	8.37	7.69	490	6506	2.2	93.5
G	N	219	1228	11.2	68.2	4.0	178	.40	20.2	65.2	.19	.18	7.02	6.62	793	5679	2.2	92.2
H	S	178	1384	17.1	67.3	3.4	201	.14	21.2	68.0	.25	.21	5.31	5.17	541	2616	2.3	92.4
I	P	201	1399	12.6	68.4	3.6	222	.16	24.4	60.8	.01	.00	10.49	10.33	963	6677	2.2	93.4
J	N	166	1441	10.9	58.4	4.9	172	.41	21.8	57.9	.13	.09	11.58	11.16	894	6729	2.3	93.1
K	P	205	1343	14.8	64.7	3.6	210	.19	21.1	64.1	.04	.03	3.50	3.33	475	2166	2.3	92.3
Penn		210	1253	12.2	68.9	3.9	194	.23	22.2	64.3	.03	.02	6.89	6.67	701	4411	2.2	93.0
Mat		193	1331	13.3	64.1	3.9	172	.34	20.8	64.0	.28	.19	8.84	8.50	565	6019	2.2	93.4

Nomenclature of Columns

f Farm

t Type N = Naturally ventilated P = Power ventilation

Day Date of visit (Julian)

time Time of day

To Temperature outside degree Celsius

RHO Relative humidity outside

Vo Wind speed outside

Dir Direction of wind, degrees

Mo Mass concentration outside, meters per sec.

T.C Temperature inside, Celsius

Rhi Relative humidity inside

Vh Air movement inside high, 1.5m, meters/sec

Vi Air movement inside low .45m, meters/sec

Mg Gross mass concentration, mg/m^3

Mn New mass concentration mg/m^3 (outside mg/m^3-Inside mg/m^3)

Co Carbon dioxide parts per million

#/lit Number density of particles, number/liter of air

med Median diameter of particles, microns

RF Respirable fraction, percent (by resistive pulse particle counter)

fitted with a Porton reticule disc for particle sizing and counting. The polarizer in the LM was used to positively identify starch particles. Other particles such as grain meal and skin were also identified with the LM but this identification was limited to the particles greater than 5.4 microns. The SEM was used to provide identification of particles as small as .52 microns.

With the SEM, it was possible to view objects at greater than a 20,000X magnification ratio, though most objects could be easily identified in the 500X to 2000X range. The identification characteristics were size, shape and surface texture. Surface texture was the primary identification tool. A high degree of accuracy was attained with high magnification ratios.

Dust samples on glass microscope slides (2.5 x 7.5 cm) were prepared according to the NIOSH method 7400 (NIOSH, 1984) as follows:

1. Glass slides and cover slips were cleaned.
2. A Guth type flask with 40 to 60 ml of acetone was stopped with a single hole rubber stopper. A glass tube extended 5 to 8 cm into the flask. The top portion of the glass tube (8 to 10 cm) was bent downward in an elbow which made an angle of 20 to 30 degrees with the horizontal.
3. The flask was placed on a stirring hot-plate and gently heated to boiling.
4. A small square (5 x 5 mm) was cut from the membrane filter with a steel curved-blade surgical knife using a rocking motion to prevent tearing.

5. Using tweezers, the filter square was placed dust side up on the slide.
6. The glass slide supporting the filter was held 1 to 2 cm from the glass tube port where the acetone vapor was escaping. The filter cleared in 2 to 5 seconds and was removed from the vapor stream.
7. A glass tube was used to place 1 to 2 drops of Triacitin on the filter. A clean 5mm round cover slip was placed on the filter.
8. The edges were glued with Permount mounting fluid using a glass rod.

Sichel's technique of truncated multiple traversing for analyzing particulates (Silverman et al. 1971) was used to size and count the particles. Identification was accomplished by comparing particles to known samples prepared in the laboratory, a picture atlas of known particles (McCrone and Delly, 1973) and photos from Hoseney et al. (1974). The prepared known samples included corn, grain sorghum, wheat, pig feces, soil and, pig epidermal skin flakes. With the exception of the skin, the samples were prepared by:

1) grinding to a fine powder using a mortar and pedestal,
2) placing sample in 35mm film container,
3) positioning the sampling unit with the cassette directly below the bottom of the tube of the Modified Martin drop tester (Heber et al. 1986),
4) placing sample in top of drop tester. Placing the film

container in bottom of drop tester (bottom gate of drop tester is secured open),

5) dropping sample and after 15 to 30 seconds removing bottom film container,

6) turning sampler on for 15 to 30 seconds as fine particles slowly settled down and out of tube, and

7) mounting samples for LM and SEM using same methods as for the farm samples. The skin was collected from a sow that had just received a bath. A blunt scraper was used to scrape off skin cells which were then tapped off the scraper on to the face of the membrane filter in a cassette.

The particulates were then analyzed with a Zeiss Polarizing Phase Contrast microscope which was fitted with a Porton reticule (Graticules Ltd., Tonbridge Kent, England). The eyepiece reticule was calibrated with a stage micrometer (BGI Inc., Waltham Mass.) according to NIOSH Standards (NIOSH, 1984).

Samples were prepared for SEM according to the following procedure:

1. A 5 x 5 mm square was cut from the membrane filter using a scalpel with a rocking motion,
2. using tweezers, the square was placed onto a clean SEM stud which had a piece of double sided laboratory tape on it,
3. Excess tape was trimmed and a dab of silver paste was placed on one edge to increase conductance during sputtering, and
4. The stubs were sputtered with an Edwards S150 sputter coater

and a gold target.

The SEM analysis was performed by placing a transparency with a Porton reticule over the SEM viewing screen. Each SEM stub was scanned at 500X before arbitrarily selecting two sites for viewing at 1000X. Each particle in the field was sized and identified using the zoom-in feature and Porton reticule. Finally, a third field was selected and photographed. It must be noted that the selection of fields was slightly biased (SEM only). After scanning the stub to note the relative density of particulates, fields of the following types were avoided when:

A) particles were crowded and lying on top of each other.

B) The field was empty, and

C) When one or two large particles occupied the entire field.

Several biases were created by this selection process.

1. The count was reduced when medium density fields were preferred on high density stubs.
2. The count was increased when high density fields were preferred on low density stubs.
3. The particle counts in the larger size ranges were decreased as the largest particles were intentionally avoided.

These biases affected the overall size distribution especially in the larger size ranges.

Results and Discussion

The Quantitative and Qualitative Analysis

The swine confinement airborne particulates were found to be diverse in size and shape, a finding in agreement with others (Donham 1986). The identified particles included the following:

1. grain meal
2. starch
3. skin
4. pollen
5. insect parts and spider webs

Light Microscopic Analysis

Sixty-six percent of the particles larger than 5.4 microns in diameter and identified with light microscopy (LM) were of grain meal origin and fifteen percent were starch (Table 3). The combined total, or the feed component, comprised a total of 81 percent of the particles greater than 5.4 microns. Donham et al. (1986) also found that feed made up the largest proportion of the particles identified in swine confinement finishing buildings.

Only 1 percent skin particles were identified (Table 3). Those that were identified were mostly confined to the size classes above 15.3 microns. Because of this very low incidence and the large size of skin particles, one might postulate that their larger size does not allow them to remain airborne for extended periods of time.

Table 3. OVERALL SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7- 3.8	3.8- 5.4	5.4- 7.8	7.8- 10.8	10.8- 15.3	15.3- 21.8	21.8- 30.5	>30.	TOTAL All	AVG # >5.4	AVG % >5.4
Total Count	8544.5	2432.0	1582.0	1286.2	1010.5	680.7	352.4	188.9	91.8	16158	323.0	
Average Percent	52.8	15.1	10.4	8.0	6.3	4.1	2.2	1.0	0.2			
Avg Cum Percent	52.8	67.8	78.3	86.3	92.8	96.8	98.8	99.8	100.0			
Avg % Starch				1.8	3.8	4.2	2.8	1.5	0.3			14
Stand Dev				1.4	1.7	1.7	1.1	0.8	0.3			
Avg % Skin				0.0	0.1	0.1	0.1	0.2	0.2			1
Stand Dev				0.0	0.2	0.1	0.1	0.1	0.2			
Avg % Grn Meal				24.8	18.8	12.0	6.7	2.8	0.7			65
Stand Dev				12.7	7.7	3.8	1.3	0.7	0.4			
Avg % Feed				25.0	21.2	19.0	8.1	8.7	1.0			74
Stand Dev				11.8	8.8	8.7	1.8	1.2	0.7			

Average Respirable Fraction = 78.3 Percent

Table 4. FARM A SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7- 3.8	3.8- 5.4	5.4- 7.8	7.8- 10.8	10.8- 15.3	15.3- 21.8	21.8- 30.5	>30.	TOTAL All	TOT # >5.4um	AVG % >5.4um
Total Count	878.0	201.0	134.0	108.0	88.5	45.4	18.8	10.1	3.5	1288.2	275.2	
Average Percent	52.0	15.8	10.5	8.3	7.2	3.8	1.5	0.8	0.3			
Avg Cum Percent	52.0	67.8	78.3	86.8	93.8	97.3	98.8	99.7	100.0			
Stand Dev	8.8	1.9	2.3	2.0	3.4	1.7	0.8	0.8	0.4			
Avg % Starch				2.3	2.7	3.1	1.7	1.1	0.4			11.2
Stand Dev				2.1	2.2	4.1	1.3	1.1	0.7			
Avg % Skin				0.0	0.7	0.0	0.1	0.1	0.1			1.0
Stand Dev				0.0	1.8	0.0	0.3	0.2	0.2			
Avg % Grn Meal				8.5	11.5	7.8	8.8	2.5	0.8			35.0
Stand Dev				12.3	8.0	4.8	1.8	1.5	1.2			
Avg % Feed				10.8	14.1	10.9	5.8	3.8	1.2			48.2
Stand Dev				12.7	8.8	8.5	2.2	1.8	1.8			

Average Respirable Fraction = 78.3 Percent

Table 5. FARM B SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7- 3.8	3.8- 5.4	5.4- 7.8	7.8- 10.8	10.8- 15.8	15.3- 21.8	21.8- 30.8	>30.	TOTAL All	TOT # >5.4um	AVG % >5.4um
Total Count	701.5	228.0	154.8	82.0	77.8	41.7	23.8	8.2	2.8	1331.1	247.1	
Average Percent	81.8	17.1	11.8	7.1	8.0	3.4	1.8	0.7	0.2			
Avg Cum Percent	81.8	88.8	80.7	87.8	93.7	97.2	88.8	88.7	100.0			
Stand Dev	48.8	14.8	8.2	8.1	4.8	2.8	1.8	0.8	0.2			
Avg % Starch				2.8	4.1	3.8	2.8	1.8	0.1			13.1
Stand Dev				2.8	4.2	2.8	1.8	0.7	0.2			.
Avg % Skin				0.8	0.3	0.8	0.1	0.2	0.8			1.1
Stand Dev				0.8	0.8	0.8	0.3	0.8	0.7			
Avg % Grn Meal				18.7	21.5	12.5	8.4	4.8	0.8			84.8
Stand Dev				8.4	8.8	4.8	1.8	8.8	0.8			
Avg % Feed				21.8	25.7	15.8	8.4	8.8	0.8			77.1
Stand Dev				11.7	8.4	4.8	1.5	8.8	0.5			

Average Respirable Fraction = 80.7 Percent

Table 6. FARM C SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7- 3.8	3.8- 5.4	5.4- 7.8	7.8- 10.8	10.8- 15.3	15.3- 21.8	21.8- 30.5	>30.	TOTAL All	TOT # >5.4um	AVG % >5.4um
Total Count	853.0	214.0	156.0	188.5	130.0	88.8	50.4	17.7	7.8	1683.8	460.8	
Average Percent	80.8	12.8	8.1	8.4	7.8	8.0	2.8	1.0	0.4			
Avg Cum Percent	80.8	83.3	72.4	81.8	88.8	88.8	88.8	88.8	100.0			
Stand Dev	8.1	3.0	2.4	8.8	2.7	1.7	1.4	0.8	0.8			
Avg % Starch				0.7	8.8	8.8	2.8	1.8	0.7			18.7
Stand Dev				1.8	4.8	8.0	2.8	2.0	1.8			
Avg % Skin				0.0	0.0	0.0	0.1	0.1	0.2			0.4
Stand Dev				0.0	0.0	0.0	0.2	0.2	0.3			
Avg % Grn Meal				25.0	22.8	18.2	7.8	2.1	1.8			75.1
Stand Dev				8.7	8.5	4.1	4.4	1.2	2.8			
Avg % Feed				26.8	26.3	22.1	10.5	3.8	2.8			81.7
Stand Dev				8.1	5.0	2.0	4.2	2.8	8.8			

Average Respirable Fraction = 72.4 Percent

Table 7.

FARM D SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.6	>30.	TOTAL All	TOT # >5.4um	AVG % >5.4um
Total Count	891.0	256.0	173.0	123.0	87.0	53.6	31.6	12.6	3.1	1631.2	311.2	
Average Percent	65.0	15.7	10.5	7.5	5.2	3.2	1.9	0.6	0.2			
Avg Cum Percent	55.0	70.7	81.1	88.6	93.8	97.1	99.0	99.8	100.0			
Stand Dev	6.6	2.3	2.4	2.0	2.1	1.3	0.6	0.2	0.2			
Avg % Starch				1.2	1.8	2.1	3.6	1.3	0.3			10.4
Stand Dev				1.6	2.4	2.2	2.8	0.7	0.4			
Avg % Skin				0.0	0.0	0.0	0.0	0.3	0.1			0.4
Stand Dev				0.0	0.0	0.0	0.0	0.3	0.2			
Avg % Grn Meal				36.0	25.4	13.2	5.8	2.3	0.4			83.1
Stand Dev				8.0	3.6	3.1	1.8	1.4	0.7			
Avg % Feed				37.3	26.6	18.3	6.7	3.6	0.7			83.5
Stand Dev				8.2	8.4	4.1	3.6	1.7	0.7			
Average Respirable Fraction =				81.1 Percent								

Table 8.

FARM E SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-8.4	8.4-7.6	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.8	>30.	TOTAL All	TOT # >8.4um	AVG % >5.4um
Total Count	805.0	227.0	144.5	100.5	84.3	65.2	22.2	8.6	1.7	1446.8	270.4	
Average Percent	57.1	15.3	6.6	8.6	8.8	3.6	1.8	0.8	0.1			
Avg Cum Percent	87.1	72.8	82.3	88.3	93.7	97.3	98.8	99.3	99.4			
Stand Dev	16.7	12.0	7.8	6.4	6.8	3.7	2.3	0.2	0.1			
Avg % Starch				0.6	2.8	2.0	2.8	0.3	0.0			6.3
Stand Dev				1.0	1.7	1.8	2.1	0.4	0.0			
Avg % Skin				0.0	0.4	0.5	0.1	0.3	0.3			1.6
Stand Dev				0.0	1.1	0.6	0.2	0.0	0.3			
Avg % Grn Meal				25.6	25.8	16.6	8.4	2.4	0.4			78.4
Stand Dev				7.5	7.2	4.7	1.7	1.2	0.4			
Avg % Feed				26.5	28.7	18.8	7.8	2.7	0.4			84.7
Stand Dev				7.8	8.8	8.6	3.2	1.8	0.4			
Average Respirable Fraction =				82.3 Percent								

Table 9.

FARM F SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-8.4	8.4-7.8	7.8-10.6	10.6-16.3	16.3-21.6	21.6-30.8	>30.	TOTAL All	TOT # >8.4um	AVG % >5.4um
Total Count	698.0	195.0	133.8	94.4	65.4	42.1	22.8	14.8	3.0	1268.8	242.4	
Average Percent	54.8	16.1	10.7	8.8	4.8	3.2	1.7	1.2	0.3			
Avg Cum Percent	54.8	71.0	81.8	88.7	93.8	96.8	98.8	99.7	100.0			
Stand Dev	5.6	4.8	2.8	2.6	1.6	1.8	1.8	1.6	0.3			
Avg % Starch				1.8	3.8	3.6	1.6	2.1	1.1			13.6
Stand Dev				1.7	3.3	4.8	1.6	2.3	2.0			
Avg % Skin				0.0	0.0	0.0	0.8	0.2	0.0			0.7
Stand Dev				0.0	0.0	0.0	0.8	0.3	0.0			
Avg % Grn Meal				18.6	18.2	10.6	4.2	2.1	1.1			50.4
Stand Dev				13.4	11.3	2.8	2.1	1.7	1.6			
Avg % Feed				18.7	18.7	14.4	6.6	4.2	2.3			84.1
Stand Dev				12.4	12.2	3.6	3.3	2.6	3.5			
Average Respirable Fraction =				81.8 Percent								

Table 10.

FARM G SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOT # >5.4um	AVG % >5.4um
Total Count	836.0	175.0	131.0	104.0	94.3	65.2	30.3	13.2	2.1	1451.0	309.0	
Average Percent	58.2	11.7	8.7	6.6	6.1	4.4	2.1	0.6	0.1			
Avg Cum Percent	58.2	70.8	78.7	85.4	92.6	96.8	98.8	99.8	100.0			
Stand Dev	10.7	3.4	2.8	2.8	3.2	2.1	1.1	0.5	0.2			
Avg % Starch				0.8	2.8	5.8	2.7	1.6	0.1			13.5
Stand Dev				1.2	3.0	4.1	2.0	2.0	0.2			
Avg % Skin				0.0	0.0	0.0	0.1	0.2	0.2			0.4
Stand Dev				0.0	0.0	0.0	0.2	0.3	0.3			
Avg % Grn Meal				30.2	24.2	15.4	7.2	2.7	0.4			80.2
Stand Dev				6.4	6.0	5.6	3.0	1.8	0.8			
Avg % Feed				30.8	27.1	21.0	8.6	4.4	0.4			83.7
Stand Dev				6.6	7.1	7.6	4.5	3.1	0.7			
Average Respirable Fraction =				76.7 Percent								

Table 11.

FARM H SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOT # >5.4um	AVG % >5.4um
Total Count	792.0	142.0	101.8	75.3	82.8	44.5	16.8	7.3	1.8	1238.7	200.2	
Average Percent	82.7	12.2	8.7	8.1	4.4	3.8	1.5	0.8	0.2			
Avg Cum Percent	82.7	75.0	83.7	88.8	94.2	97.8	99.3	99.8	100.0			
Stand Dev	13.8	2.8	3.4	2.9	8.2	8.2	0.8	0.5	0.2			
Avg % Starch				0.1	1.8	3.4	2.1	0.7	0.2			8.1
Stand Dev				0.4	2.0	4.0	2.5	1.1	0.8			
Avg % Skin				0.0	0.2	0.2	0.0	0.1	0.0			0.5
Stand Dev				0.0	0.8	0.8	0.0	0.2	0.0			
Avg % Grn Meal				40.2	24.1	13.2	8.8	1.7	1.8			87.4
Stand Dev				18.3	7.8	8.3	8.8	2.2	8.2			
Avg % Feed				40.4	25.7	18.8	8.8	2.4	1.5			85.5
Stand Dev				18.2	7.4	7.3	3.8	2.8	8.1			

Average Respirable Fraction = 83.7 Percent

Table 12.

FARM I SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.6	>30.	TOTAL All	TOT # >8.4um	AVG % >5.4um
Total Count	888.0	236.0	172.0	150.0	101.4	60.8	34.5	11.8	4.1	1806.1	882.1	
Average Percent	52.8	14.8	10.5	8.2	8.8	3.7	2.1	0.7	0.3			
Avg Cum Percent	82.5	87.2	77.7	86.8	93.1	86.8	88.0	88.7	100.0			
Stand Dev	8.8	2.8	2.8	2.3	3.1	1.8	0.8	0.2	0.2			
Avg % Starch				1.0	4.0	4.2	2.8	1.2	0.2			18.1
Stand Dev				1.8	4.8	2.8	2.3	1.1	0.2			
Avg % Skin				0.0	0.0	0.0	0.0	0.3	0.7			1.0
Stand Dev				0.0	0.0	0.0	0.0	0.8	0.4			
Avg % Grn Meal				35.8	20.4	11.8	8.8	1.7	0.3			78.1
Stand Dev				12.7	8.2	4.8	2.2	0.8	0.3			
Avg % Feed				36.8	24.4	18.8	8.1	2.8	0.8			86.2
Stand Dev				12.8	10.8	4.0	8.3	0.7	0.8			

Average Respirable Fraction = 77.7 Percent

Table 13.

FARM J SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOT # >5.4um	AVG % >5.4um
Total Count	999.0	265.0	204.0	133.0	108.5	78.0	55.1	42.6	0.0	1487.2	419.2	
Average Percent	40.8	17.2	14.2	8.8	7.3	5.2	3.8	3.0	0.0			
Avg Cum Percent	40.8	57.8	72.0	80.8	87.8	93.1	97.0	100.0	100.0			
Stand Dev	7.5	2.8	4.7	2.4	1.8	1.8	2.8	2.1	0.0			
Avg % Starch				4.7	7.8	8.8	5.4	3.8	0.0			28.8
Stand Dev				2.3	3.8	4.1	4.8	4.7	0.0			
Avg % Skin				0.0	0.0	0.0	0.0	0.3	0.8			0.8
Stand Dev				0.0	0.0	0.0	0.0	0.5	1.2			
Avg % Grn Meal				0.2	0.8	3.1	3.8	2.7	0.5			11.2
Stand Dev				0.8	1.7	1.8	2.8	1.2	1.8			
Avg % Feed				4.8	8.8	10.0	8.3	8.5	0.5			38.8
Stand Dev				2.8	8.8	4.4	8.5	8.8	1.5			

Average Respirable Fraction = 72.0 Percent

Table 14.

FARM K SUMMARY

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-18.8	18.3-21.8	21.8-30.8	>80.	TOTAL All	TOT # >8.4um	AVG % >5.4um
Total Count	854.0	293.0	178.0	148.5	118.8	73.8	44.8	12.4	2.8	1727.8	402.8	
Average Percent	80.8	18.8	10.1	8.3	8.8	4.1	2.5	0.7	0.1			
Avg Cum Percent	80.8	87.5	77.8	85.8	92.8	96.7	99.1	99.8	100.0			
Stand Dev	10.8	8.8	2.8	3.3	2.8	2.2	2.8	0.5	0.1			
Avg % Starch				3.3	4.0	5.2	8.8	1.4	0.8			17.7
Stand Dev				3.0	4.0	4.8	3.8	1.3	0.4			
Avg % Skin				0.0	0.0	0.0	0.1	0.2	0.1			0.5
Stand Dev				0.0	0.0	0.0	0.3	0.3	0.2			
Avg % Grn Meal				35.8	24.8	12.8	5.8	1.8	0.4			80.8
Stand Dev				14.4	3.8	4.8	4.0	0.8	0.3			
Avg % Feed				38.2	28.5	17.8	8.8	2.8	0.7			88.5
Stand Dev				15.2	8.0	6.3	7.2	2.0	0.8			

Average Respirable Fraction = 77.8 Percent

The respirable fraction (percent smaller than 5.4 microns) of the airborne particles was over 78 percent. This is slightly lower than the results obtained by a resistive pulse particle sizer to analyze size distribution for the same study (Stroik and Heber, 1986). The greater incidence of respirable particles measured by the resistive pulse particle sizer was most likely a result of smaller particles being counted and also the deagglomerations of some of the larger aggregates in the electrolyte in which the particles were suspended for counting.

It is interesting to note that there was relatively little variation in the Average Respirable Fraction (ARF) between farms. The lowest ARF was 72.0 percent from Farm J and the highest was 83.7 from Farm H (Tables 4-14).

Scanning Electron Microscope Analysis

The particles identified with the SEM ranged from 1 micron to approximately 30 microns. Shape and surface texture were the primary basis for identifications. Starch particles were round or polygonal and relatively smooth. Grain meal particles were large, irregular and plated or layered on their surface. Skin was flat with smooth to slight but regular pitting. Many skin particles were also folded near the edges.

Interestingly, the SEM percentages of identified components paralleled the LM analysis. Grain meal made up 65 percent of both the SEM particles (Table 15 and Figure 1) and of the LM (Table 3). Starch

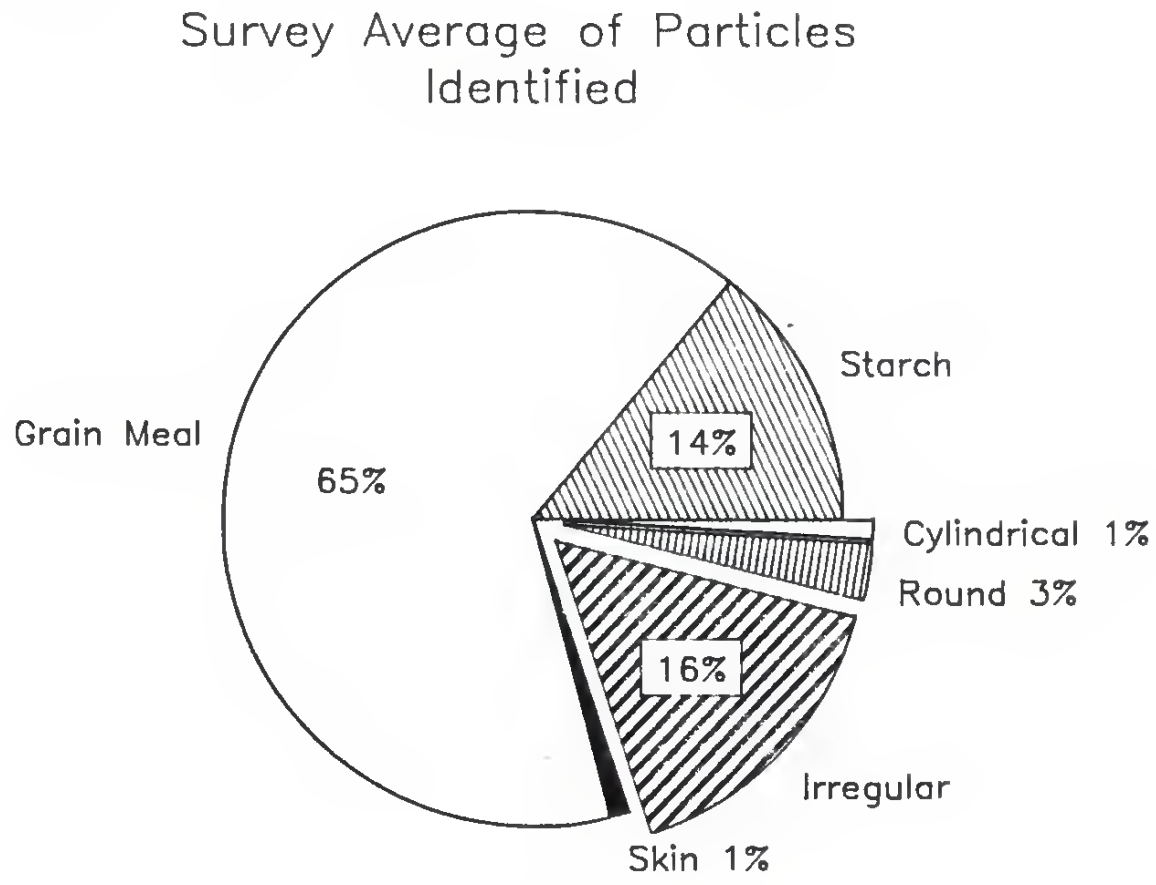
Table 15. SUMMARY
ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE			SHAPE		
	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
VISIT 1	21	1	48	17	7	3
VISIT 2	19	1	70	24	8	0
VISIT 3	19	0	124	26	6	5
VISIT 4	29	0	194	39	13	3
VISIT 5	37	5	137	20	4	3
VISIT 6	26	3	117	36	1	2
VISIT 7	17	6	94	20	4	2
VISIT 8	38	1	204	55	10	0
TOTALS	206	17	988	237	53	18
OVERALL TOTAL =	1519					

SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	23	0	0
1.68 - 2.1	1	0	24	76	14	3
2.1 - 3.36	3	0	118	66	29	3
3.36 - 4.2	13	0	131	34	7	4
4.2 - 6.72	52	1	252	21	3	2
6.72 - 8.4	54	0	146	7	0	2
8.4 - 10.3	30	0	114	4	0	3
10.3 - 20.0	29	5	123	5	0	1
> 20.0	24	10	80	1	0	0
TOTAL	206	16	988	237	53	18
% TOTAL	14	1	65	16	3	1
% FEED =	79					

Figure 1.



Scanning Electron Microscopy

also made up 14 percent for both methods. The correlation coefficient between the two methods for individual samples, however, was low. The low correlation coefficient was probably due to the lower particle counts per sample (average = 20) and non-standard method used with the SEM. Skin was found to make up 1 percent of the particles for both methods.

The SEM analysis covered a smaller range of size than the LM, Figure 2. The difference on the lower end of the scale can be explained by differences in the capabilities of the two methods. The LM method was limited because of the relatively low magnification ratio of 160X. Particles below 3.8 microns were difficult to identify. Particles in the smallest size class (less then 2.1) were counted and included in the size distribution. It is likely that any particles smaller than 1 micron were not visible at 160X. The SEM waa used to provide a better analysis of particles smaller than 20 microns. When using the SEM, an interesting phenomenon was found when examining the blank filters. The surface structure could be clearly seen at 2000X. The surface appeared to look spongelike and the surface pore size varied greatly. The larger pores were up to 3 microns across. This made it possible for smaller particles to be trapped just below the surface. Once in this position combined with the irregular surface texture, many particles smaller than 1.5 microns were difficult to distinguish from the membrane filter surface.

A similar study (Donham et al. 1986) found that feed and fecal material made up the major component of particles identified. The fecal materials included bacteria, gut epithelial cells and undigested

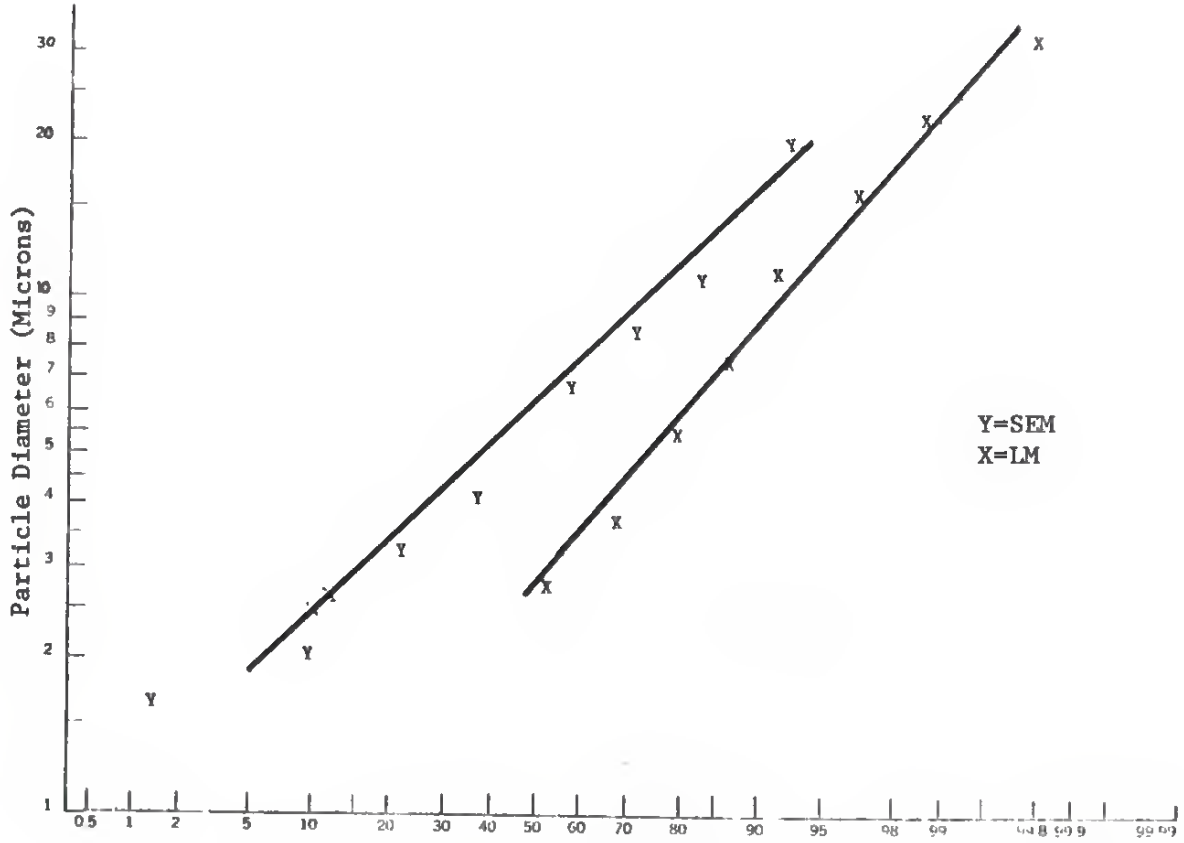


Figure 2 Cumulative Percent Less Than or Equal to Stated Diameter

Size Distribution of particles Identified by SEM and LM.

feed. Perhaps in this study, the feed that was identified may have been undigested feed, and some of the skin particles may have been gut epithelial cells both of fecal origin.

Conclusions

Analysis by light microscopy and scanning electron microscopy revealed the airborne swine house particules to be diverse in both shape and size. Particles identified included, grain meal, starch, skin, pollen, insect parts and spider webs (Figure 3). The size distributions were linear on a log-probability scale (Figure 2). Seventy-nine percent of the particles were feed by LM analysis and also the SEM analysis (Table 123 and 135). The feed component was divided into starch and non-starch or grain meal components. Grain meal was 65 percent by SEM and 66 percent by LM. Starch was found to be 15 percent by LM. Feed particles made up the greatest percentage of the swine finishing house airborne particles, a finding similar to those of others (Donham et al. (1986); Chiba et al. (1986); Curtis et al. (1975); Honey and Mcquitty (1979); and Hovmand and Slot (1968)).

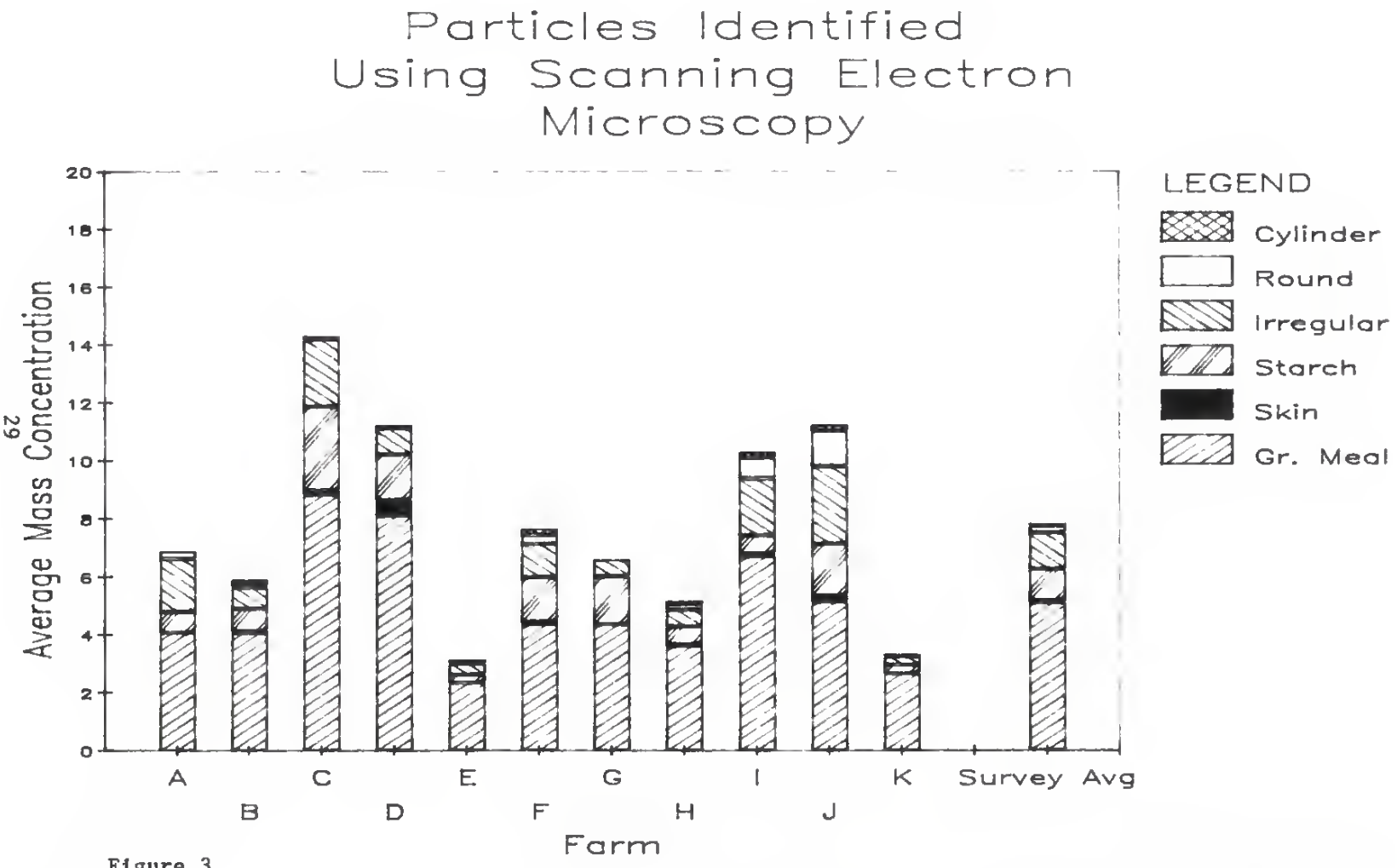


Figure 3.

Each bar has been divided by percentage of particles identified

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Appendex A
Supplemental lnformation on Sampled Finishing Units

The following is a complete description of each swine finishing unit sampled in the survey. Only one building per farm was selected. The management practices were described as follows:

Excellent - Unit always very clean and well maintained

Good - Unit usually clean and adequately maintained

Fair - Unit sometimes dirty, maintained at minimum level

Poor - Unit always dirty and minimally maintained

ln all cases MOF buildings had manually operated doors in the back sidewall. Automatic augers and sprinklers were controlled by a timer and automatic curtains were controlled by a thermostat.

Farm A: Humbolt Haven. Located 15 miles S. E. of Junction City in Geary County. Management practices were good. Augers and sprinklers were automatic. Located 30 feet East was a nursery. Located 30 feet North was a farrowing house. No other buildings in general vicinity.

Farm B: F and R Swine. Located 16 miles S. E. of Junction City in Geary County. Management practices were good. Augers were automatic. The building was over 900 feet long and partitioned into 3 equal sections. The area sampled was located on the South end. Located East were two other equal sized buildings running parallel and spaced about 30 feet apart. South 100 feet was a machine shed. Beyond that shed were a variety of other pig units and residences.

Farm C: Owner, Guy McDiffit. Located 3 miles West of Alma in Wabaunsee County. Management practices were poor. The eight year old unit had never been cleaned. Settled dust was thick and cobwebs were a problem in cold weather. Augers were manual, sprinklers and front curtain were automatic. Located South 40 feet was a farrowing/nursery unit of similar size. A machine shed was located 15 feet West and extended 50 feet South. A loading ramp was attached to the West end of the sampled unit and extended behind the machine shed.

Farm D: Spring Creek Hogs, Inc. Located 4 miles East of Paxico in Wabaunsee County. Management practices were fair. Augers and sprinklers were manual. Sprinklers ran continuously when in use and the front curtain was automatic. In January there was a large gap in the West end of the curtain (was never fixed). Thereafter, the West end of the building was much cooler then the East end. Located 35 feet North and running parallel was a similar unit. Beyond that unit 35 feet was another unit. All units were set into the South slope of a hill.

Farm E: Owner, Dave Carnahan. Located 1 mile West of Wamego in Pottawatomie County. Management practices were good. Augers and sprinklers were automatic. The front of the building had fold down panels that were manually operated. The unit was partitioned into 3 equal rooms with the aisle open. Sampling was performed in the center section. Air temperature and relative humidity were measured at the center of each room. Located East 40 feet was a small

farrowing/nursery unit which ran North to South.

Farm F: Owner, Roy Henry. Located 2 miles North of Longford in Clay County. Management practices were excellent. The unit was power washed between groups of pigs. Auger and front curtain were automatic. Located North 25 feet and running parallel was a complex of 3 connecting units. A runway at the center of the unit connected the sampled unit to the complex. Located East 30 feet were 3 units spaced 15 feet apart from each other. The center unit being in line with the sampled unit. Located S.E. 40 feet was a small hay shed.

Farm G: Owner, Fred Heigle. Located 3 miles East of Longford in Clay County. Management practices were fair. Augers and front doors were manual. Located 30 feet West was a farrowing/nursery unit running North to South. North 50 feet was a small shed. Other assorted farm buildings were located North of this shed.

Farm H: Owner, Vinton Vissor. Located 3 miles East of Riley in Riley County. Management practices were good. Augers and front curtain were automatic. Located 60 feet South and running parallel was a unit of similar size. Located 200 feet beyond that unit was the farmstead and assorted buildings.

Farm I: Owner, Hayes Beck. Located 10 miles South of Junction City in Geary County. Management practices were poor until Beck bought the unit in August and management then steadily improved. The unit was

in two parts joined by a small hall. The section sampled was on the North. It was divided into 3 pens with no aisle. Sampler was placed in the hall. Pit fans and an open door on the North were the only source of ventilation. Initially the fans were set at a low rate. Beck adjusted the fans for maximum airflow to improve ventilation. Located 50 feet Southwest was a small barn. 75 feet Southeast was a house.

Farm J: Owner, Bruce Wolf. Located 2 miles South of Longford in Dickinson County. Management practices were good. Augers and front doors were manual. Located 30 feet Southeast was a farrowing/nursery unit which ran North to South.

Farm K: Owner, Hayes Beck. Located 9 miles South of Junction City in Geary County. Management practices were excellent. The unit was used to raise purebred breeding stock. Aisles were swept daily and pens scraped often. Pigs were hand fed twice daily. The unit was partitioned into 3 sections. The North room was sampled. Located West 30 feet was a line of trees. South 50 feet was a wooded area.

Table 16. VISIT A-1

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	63.00	25.00	14.00	15.00	14.00	3.33	2.20	2.40	0.80	140	36	
Overall %	45.1	17.6	10.0	10.7	10.0	2.4	1.6	1.7	0.6			
Cumulative %	45.1	63.0	73.0	83.7	93.6	96.1	97.7	99.4	100.0			
Starch #/T	0.00	0.00	0.00	2.00	1.00	0.33	0.60	0.40	0.60			
% (>5.4 um)				5.3	2.7	0.9	1.6	1.1	1.6			13.1
Skin #/T	0.00	0.00	0.00	0.00	2.00	0.00	0.20	0.00	0.00			
% (>5.4 um)				0.0	5.3	0.0	0.5	0.0	0.0			5.8
Grain Meal #/T	0.00	0.00	0.00	2.00	3.00	1.33	1.00	1.50	0.00			
% (>5.4 um)				5.3	8.0	3.5	2.7	4.2	0.0			23.7
Feed %(>5.4 um)				10.6	10.6	4.4	4.2	5.3	1.6			36.7

Respirable Fraction = 73.0 Percent

Table 17. VISIT A-2

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	66.00	23.00	14.00	13.00	14.00	11.00	5.00	3.30	1.75	151	48	
Overall %	43.7	15.2	9.3	8.6	9.3	7.3	3.3	2.2	1.2			
Cumulative %	43.7	58.5	68.2	76.8	86.1	93.3	96.7	98.6	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.33	0.66			
% (>5.4 um)				0.0	0.0	2.1	2.1	0.7	1.4			6.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.00	0.00	1.00	2.00	3.00	1.66	1.66			
% (>5.4 um)				0.0	2.1	4.2	6.2	3.5	3.5			18.4
Feed %(>5.4 um)				0.0	2.1	6.2	8.3	4.1	4.8			25.6

Respirable Fraction = 68.2 Percent

Table 18. VISIT A-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	64.00	21.00	13.00	10.00	10.00	3.67	1.25	1.33	0.44	133	35	
Overall %	48.2	15.8	6.8	7.5	13.6	2.8	0.6	1.5	0.3			
Cumulative %	48.2	64.1	73.9	81.4	95.0	97.7	98.7	98.7	100.0			
Starch #/T	0.00	0.00	0.00	0.00	2.00	0.30	5.13	0.00	0.00			
% (>5.4 um)				0.0	5.8	0.8	0.4	0.0	0.0			7.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.6			0.6
Grain Meal #/T	0.00	0.00	0.00	1.00	7.00	0.30	0.75	1.20	0.33			
% (>5.4 um)				2.6	20.2	0.6	2.2	3.5	1.0			30.5
Feed %(>5.4 um)				2.8	25.6	1.7	2.6	3.5	1.0			37.5

Respirable Fraction = 73.8 Percent

Table 19. VISIT A-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	75.00	21.00	12.00	7.00	7.00	6.50	2.00	0.63	0.13	131	23	
Overall %	57.1	16.0	9.1	5.3	5.3	5.0	1.5	0.5	0.1			
Cumulative %	57.1	73.1	82.3	87.8	93.0	97.8	99.4	99.6	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.50	1.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	2.2	4.3	0.0	0.0			8.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.00	0.00	2.00	3.00	0.50	0.50	0.20			
% (>5.4 um)				0.0	8.6	12.9	2.8	2.6	0.6			27.5
Feed %(>5.4 um)				0.0	8.6	15.1	6.9	2.6	0.6			34.0

Respirable Fraction = 82.3 Percent

Table 20. VISIT A-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.9	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	75.00	21.00	18.00	12.00	9.00	3.25	1.43	1.11	0.22	138	24	
Overall %	54.3	15.2	13.0	8.7	6.3	2.4	1.0	0.8	0.2			
Cumulative %	54.3	69.6	82.6	91.3	95.6	98.0	99.0	99.8	100.0			
Starch #/T	0.00	0.00	0.00	1.00	0.50	0.00	0.57	0.88	0.11			
% (>5.4 um)				4.2	2.1	0.0	2.4	2.7	0.5			11.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.00	0.00	1.00	2.00	0.71	0.88	0.11			
% (>5.4 um)				0.0	4.2	8.3	3.0	2.7	0.5			18.7
Feed %(>5.4 um)				4.2	8.2	8.3	5.3	5.5	0.8			30.5

Respirable Fraction = 82.6 Percent

Table 21. VISIT A-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.9	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	100.00	29.00	18.00	10.00	6.50	4.67	2.75	1.25	0.13	171	25	
Overall %	58.4	16.3	10.5	5.8	3.8	2.7	1.6	0.7	0.1			
Cumulative %	58.4	74.7	85.2	91.1	94.9	97.6	99.2	99.9	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.50	3.00	0.50	0.38	0.00			
% (>5.4 um)				4.0	5.8	11.8	2.0	1.5	0.0			25.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.4	0.0			0.4
Grain Meal #/T	0.00	0.00	0.00	1.00	1.00	1.67	1.75	0.75	0.10			
% (>5.4 um)				4.0	4.0	6.8	6.8	3.0	0.4			24.8
Feed %(>5.4 um)				7.9	9.8	19.5	8.8	4.4	0.4			50.0

Respirable Fraction = 85.2 PERCENT

Table 22. VISIT A-7

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.6	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	150.00	28.00	18.00	23.00	12.00	7.33	2.75	0.00	0.00	242	45	
Overall %	62.0	12.0	7.4	9.5	5.0	3.0	1.1	0.0	0.0			
Cumulative %	62.0	73.8	81.4	90.8	95.8	98.8	100.0	100.0	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.00	3.00	0.25	0.00	0.00			
% (>5.4 um)				2.2	2.2	8.7	0.8	0.0	0.0			11.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.8	0.8	0.0			1.1
Grain Meal #/T	0.00	0.00	0.00	12.00	6.00	5.00	2.00	0.00	0.00			
% (>5.4 um)				26.8	17.7	11.1	4.4	0.0	0.0			59.9
Feed %(>5.4 um)				26.8	20.0	17.7	5.0	0.0	0.0			71.5

Respirable Fraction = 81.4 Percent

Table 23. VISIT A-8

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	88.00	33.00	27.00	16.00	11.00	5.67	1.37	0.10	0.00	183	37	
Overall %	47.0	18.0	14.7	10.4	8.0	3.1	0.7	0.1	0.0			
Cumulative %	47.0	65.0	79.7	90.1	98.1	99.2	99.9	100.0	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.00	0.00	0.13	1.00	0.00			
% (>5.4 um)				2.7	2.7	0.0	0.3	2.7	0.0			8.4
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	4.00	11.00	10.00	5.90	1.25	0.13	0.00			
% (>5.4 um)				29.8	28.9	15.1	3.4	0.3	0.0			75.3
Feed %(>5.4 um)				32.3	28.8	15.1	3.7	3.0	0.0			83.7

Respirable Fraction = 79.7 Percent

Table 24. VISIT B-1

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.9	10.9-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	37.00	16.00	12.00	9.50	8.00	5.50	2.50	1.40	0.40	82	27	
Overall %	40.1	17.3	13.0	10.3	8.7	6.0	2.7	1.5	0.4			
Cumulative %	40.1	57.4	70.4	80.7	89.4	95.3	98.0	99.5	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.39	0.13			
% (>5.4 um)				0.0	0.0	0.0	3.7	1.4	0.5			5.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	1.4	0.0			1.4
Grain Meal #/T	0.00	0.00	1.00	1.00	4.00	4.00	2.00	4.00	0.25			
% (>5.4 um)				3.7	14.7	14.7	7.3	14.7	0.9			55.9
Feed %(>5.4 um)				3.7	14.7	14.7	11.0	19.0	1.4			91.4

Respirable Fraction = 70.4 Percent

Table 25. VISIT B-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.9	3.8-5.4	5.4-7.9	7.8-10.8	10.8-15.3	15.3-21.8	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	157.00	49.00	33.00	21.00	19.00	5.90	4.60	2.20	0.90	299	50	
Overall %	54.5	19.7	11.5	7.3	5.9	1.9	1.9	0.9	0.2			
Cumulative %	54.5	71.2	82.9	89.9	95.5	97.4	99.0	99.9	100.0			
Starch #/T	0.00	0.00	0.00	0.00	2.00	0.75	0.90	0.90	0.00			
% (>5.4 um)				0.0	4.0	1.5	1.2	1.2	0.0			7.9
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	3.00	5.00	8.00	3.50	2.75	2.00	0.90			
% (>5.4 um)				10.0	18.0	7.0	5.5	4.0	1.2			45.7
Feed %(>5.4 um)				10.0	22.0	9.5	9.7	5.2	1.2			53.9

Respirable Fraction = 82.6 Percent

Table 26. VISIT B-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.9	7.6-10.8	10.8-15.3	15.3-21.9	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	130.00	40.00	31.00	22.00	19.00	10.00	5.00	1.30	0.75	259	57	
Overall %	50.4	15.5	12.0	8.5	7.0	3.8	1.8	0.5	0.3			
Cumulative %	50.4	65.9	77.9	86.4	93.4	97.3	99.2	99.7	100.0			
Starch #/T	0.00	0.00	0.00	3.00	3.00	1.00	0.50	0.00	0.00			
% (>5.4 um)				5.3	5.3	1.8	0.9	0.0	0.0			13.1
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	4.00	11.00	10.00	9.00	4.50	1.00	0.75			
% (>5.4 um)				19.3	17.5	15.8	7.9	1.8	1.3			93.5
Feed %(>5.4 um)				24.5	22.8	17.5	9.9	1.8	1.3			79.7

Respirable Fraction = 77.9 Percent

Table 27. VISIT B-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.9	3.8-5.4	5.4-7.9	7.6-10.8	10.9-15.3	15.3-21.9	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	123.00	47.50	29.50	10.00	11.00	9.00	5.50	2.40	0.20	235	39	
Overall %	52.3	20.2	11.3	4.3	4.7	3.9	2.3	1.0	0.1			
Cumulative %	52.3	72.5	83.9	99.0	92.7	96.9	98.9	99.8	100.0			
Starch #/T	0.00	0.00	0.00	0.50	2.00	3.00	1.00	0.90	0.00			
% (>5.4 um)				1.3	5.2	7.9	2.9	2.1	0.0			19.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.50	4.00	9.50	9.00	9.00	2.60	0.90	0.20			
% (>5.4 um)				17.1	15.7	15.7	9.9	2.1	0.5			59.0
Feed %(>5.4 um)				19.4	21.0	23.9	9.4	4.2	0.5			77.3

Respirable Fraction = 83.9 Percent

Table 28. VISIT B-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	103.00	39.00	25.00	14.00	11.00	3.80	2.78	0.90	0.50	200	33	
Overall %	51.5	19.0	13.0	7.0	5.5	1.8	1.4	0.5	0.3			
Cumulative %	51.8	70.8	83.8	90.8	96.1	97.9	99.3	99.7	100.0			
Starch #/T	0.00	0.00	0.00	2.00	4.00	2.00	0.75	0.20	0.10			
% (>5.4 um)				8.1	12.2	8.1	2.3	0.8	0.3			27.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.8			0.8
Grain Meal #/T	0.00	0.00	4.00	10.00	7.00	2.33	2.00	0.30	0.20			
% (>5.4 um)				30.5	21.4	7.1	6.1	0.8	0.8			86.7
Feed %(>5.4 um)				38.6	33.8	13.2	8.4	1.5	0.8			94.3

Respirable Fraction = 83.8 PERCENT

Table 29. VISIT B-7

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	101.00	21.00	15.00	8.00	8.50	4.00	2.00	0.28	0.00	180	23	
Overall %	83.2	13.1	9.4	5.0	5.3	2.5	1.3	0.2	0.0			
Cumulative %	83.2	78.4	85.8	90.8	96.1	98.6	99.8	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.80	0.80	0.33	0.25	0.25	0.00			
% (>5.4 um)				2.2	2.2	1.5	1.1	1.1	0.0			9.0
Skin #/T	0.00	0.00	0.00	0.00	0.80	0.00	0.20	0.00	0.20			
% (>5.4 um)				0.0	2.2	0.0	0.9	0.0	0.8			4.0
Grain Meal #/T	0.00	0.00	9.00	5.50	8.50	3.80	1.40	0.40	0.00			
% (>5.4 um)				24.2	37.4	16.8	6.2	1.8	0.0			86.3
Feed %(>5.4 um)				28.4	39.8	17.3	7.3	2.8	0.0			93.3

Respirable Fraction = 85.8 Percent

Table 30. VISIT B-8

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	80.80	17.50	11.00	7.50	8.00	4.00	1.50	0.73	0.48	88	15	
Overall %	51.4	17.8	11.2	7.8	8.1	4.1	1.8	0.7	0.5			
Cumulative %	51.4	99.3	90.5	98.1	93.2	97.3	99.8	99.5	100.0			
Starch #/T	0.00	0.00	0.00	1.00	0.00	0.50	0.38	0.13	0.00			
% (>5.4 um)				5.2	0.0	2.8	2.0	0.7	0.0			10.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	1.7			1.7
Grain Meal #/T	0.00	0.00	2.00	5.00	5.00	2.25	1.00	0.53	0.20			
% (>5.4 um)				26.1	26.1	11.7	5.2	2.8	1.0			72.8
Feed %(>5.4 um)				31.3	29.1	14.3	7.2	3.5	1.0			86.3

Respirable Fraction = 80.8 Percent

Table 31. VISIT C-1

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	98.00	23.00	22.00	33.00	24.00	15.00	12.00	1.87	0.87	230	88	
Overall %	43.0	10.0	9.8	14.3	10.4	6.5	5.2	0.7	0.3			
Cumulative %	43.0	53.0	82.5	78.8	87.3	93.8	98.0	98.7	100.0			
Starch #/T	0.00	0.00	0.00	0.00	1.00	3.00	0.00	0.33	0.00			
% (>5.4 um)				0.0	1.2	3.5	0.0	0.4	0.0			5.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.2	0.0			0.2
Grain Meal #/T	0.00	0.00	8.00	20.00	21.00	17.00	12.00	1.15	0.87			
% (>5.4 um)				23.2	24.3	18.7	13.8	1.3	0.8			83.2
Feed %(>5.4 um)				23.2	25.5	23.2	13.8	1.7	0.8			88.2

Respirable Fraction = 82.5 Percent

Table 32. VISIT C-2

SIZE CLASSES, MICRONS

VARIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.5	7.6-10.8	10.9-15.3	15.3-21.8	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	117.00	24.00	23.00	19.00	13.00	13.00	10.00	2.20	1.80	222	58	
Overall %	52.5	10.8	10.4	8.1	5.5	5.8	4.5	1.0	0.7			
Cumulative %	52.9	83.6	73.8	82.1	87.5	93.8	98.3	99.3	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	4.00	2.00	1.20	1.00			
% (>5.4 um)				0.0	0.0	8.5	3.5	2.1	1.7			14.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.3			0.3
Grain Meal #/T	0.00	0.00	1.00	11.00	11.00	8.00	8.00	1.00	4.00			
% (>5.4 um)				18.0	18.0	13.5	13.8	1.7	5.9			74.4
Feed %(>5.4 um)				19.0	15.0	20.9	17.3	3.9	9.7			86.5

Respirable Fraction = 73.9 Percent

Table 33. VISIT C-3

SIZE CLASSES, MICRONS

VARIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.5	7.6-10.8	10.6-15.3	15.3-21.8	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	72.00	11.00	9.00	23.00	18.00	14.00	3.30	1.10	0.00	151	58	
Overall %	47.8	7.3	5.8	15.2	11.8	8.2	2.2	0.7	0.0			
Cumulative %	47.8	54.5	60.8	76.0	87.8	97.1	99.3	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	1.00	1.00	0.50	0.10	0.00			
% (>5.4 um)				0.0	1.7	1.7	0.9	0.2	0.0			4.4
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	3.00	18.00	15.00	12.00	3.00	0.88	0.00			
% (>5.4 um)				25.8	25.3	20.2	5.1	1.5	0.0			78.9
Feed %(>5.4 um)				28.8	28.9	21.8	5.8	1.7	0.0			83.3

Respirable Fraction = 80.8 Percent

Table 34. VISIT C-4

SIZE CLASSES, MICRONS

VARIABLE	<2.7	2.7-3.9	3.9-5.4	5.4-7.8	7.6-10.8	10.6-15.3	15.3-21.8	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	131.00	31.00	13.00	11.00	12.00	10.00	7.00	4.30	3.00	222	47	
Overall %	59.0	13.9	5.8	4.8	5.4	4.5	3.1	1.8	1.3			
Cumulative %	58.9	72.8	78.7	83.7	[illegible]	93.5	96.7	99.7	100.0			
Starch #/T	0.00	0.00	0.00	2.00	2.00	5.00	[illegible]	[illegible]	1.70			
% (>5.4 um)				4.2	4.2	10.8	8.5	5.7	3.8			37.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	2.00	9.00	8.00	5.00	1.70	1.70	1.30			
% (>5.4 um)				19.8	18.0	10.8	3.6	3.8	2.7			58.4
Feed %(>5.4 um)				21.1	23.3	21.1	13.1	8.3	8.3			94.3

Respirable Fraction = 78.7 Percent

Table 35. VISIT C-5

SIZE CLASSES, MICRONS

VARIABLE	<2.7	2.7-3.5	3.6-5.4	5.4-7.8	7.6-10.8	10.6-15.3	15.3-21.8	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	102.00	31.00	26.00	21.00	15.00	11.00	7.00	2.75	1.25	217	58	
Overall %	47.0	14.3	12.0	9.7	6.9	5.1	3.2	1.3	0.9			
Cumulative %	47.0	91.3	73.3	82.8	88.9	94.9	98.2	99.4	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.00	2.00	1.00	0.25	0.25			
% (>5.4 um)				1.7	1.7	3.4	1.7	0.4	0.4			9.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.4			0.4
Grain Meal #/T	0.00	0.00	2.00	19.00	12.00	8.00	8.00	2.50	0.75			
% (>5.4 um)				27.8	20.7	18.5	10.3	4.3	1.3			78.7
Feed %(>5.4 um)				28.3	22.4	18.0	12.1	4.7	1.7			89.2

Respirable Fraction = 73.3 Percent

Table 36. VISIT C-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.8-5.4	5.4-7.5	7.8-10.6	10.6-15.3	15.3-21.5	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	105.00	31.00	27.00	22.00	26.00	16.00	5.00	2.50	0.75	236	73	
Overall %	44.4	13.1	11.4	9.3	10.6	7.6	2.1	1.1	0.3			
Cumulative %	44.4	57.6	68.0	76.3	88.8	86.5	66.6	99.7	100.0			
Starch #/T	0.00	0.00	0.00	0.00	8.00	6.00	1.50	0.25	0.00			
% (>5.4 um)				0.0	6.2	12.3	2.0	0.3	0.0			22.6
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.60			
% (>5.4 um)				0.0	0.0	0.0	0.7	0.7	0.7			2.0
Grain Meal #/T	0.00	5.00	26.00	22.00	16.00	6.00	3.00	1.75	0.25			
% (>5.4 um)				30.0	25.6	12.3	4.1	2.4	0.3			75.1
Feed %(>5.4 um)				30.0	34.1	24.6	6.1	2.7	0.3			66.0

Respirable Fraction = 66.0 PERCENT

Table 37. VISIT C-7

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.8-5.4	5.4-7.6	7.8-10.6	10.8-15.3	15.3-21.6	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	110.00	32.00	14.00	6.50	11.00	6.50	2.75	2.40	0.20	160	34	
Overall %	57.8	16.8	7.4	5.0	5.8	4.5	1.4	1.3	0.1			
Cumulative %	57.8	74.6	82.0	86.6	92.7	97.2	98.8	98.6	100.0			
Starch #/T	0.00	0.00	0.00	0.00	4.50	5.00	1.25	1.20	0.00			
% (>5.4 um)				0.0	13.1	14.6	3.6	3.5	0.0			34.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	1.00	6.00	6.50	3.50	1.50	0.40	0.20			
% (>5.4 um)				26.2	16.6	10.2	4.4	1.2	0.6			61.4
Feed %(>5.4 um)				26.2	32.0	24.7	6.0	4.7	0.6			66.2

Respirable Fraction = 62.0 Percent

Table 38. VISIT C-8

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.8-5.4	5.4-7.6	7.8-10.6	10.8-15.3	15.3-21.6	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	117.00	31.00	22.00	16.00	12.00	10.00	3.33	0.76	0.06	214	44	
Overall %	54.8	14.5	10.3	6.4	5.6	4.7	1.8	0.4	0.0			
Cumulative %	54.6	69.1	79.4	87.6	93.4	98.1	99.6	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.15	0.00			
% (>5.4 um)				0.0	0.0	2.3	2.3	0.3	0.0			4.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.2			0.2
Grain Meal #/T	0.00	0.00	4.00	17.00	12.00	8.50	2.33	0.46	0.00			
% (>5.4 um)				36.5	27.2	19.2	5.3	1.0	0.0			61.2
Feed %(>5.4 um)				36.5	27.2	21.5	7.5	1.4	0.0			88.1

Respirable Fraction = 76.4 Percent

Table 39. VISIT D-1

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.8-5.4	5.4-7.8	7.8-10.6	10.6-15.3	15.3-21.6	21.8-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	133.00	26.00	17.00	10.00	6.00	2.75	2.50	1.14	0.14	166	22	
Overall %	67.3	13.2	6.8	5.1	2.5	1.4	1.3	0.6	0.1			
Cumulative %	67.3	80.5	88.1	94.2	98.7	98.1	98.4	98.6	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.43	0.14			
% (>5.4 um)				0.0	0.0	0.0	4.6	2.0	0.7			7.3
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.7	0.0			0.7
Grain Meal #/T	0.00	0.00	1.00	6.00	5.00	2.75	1.25	0.57	0.00			
% (>5.4 um)				41.6	23.2	12.6	5.6	2.6	0.0			68.3
Feed %(>5.4 um)				41.6	23.2	12.6	10.5	4.6	0.7			63.5

Respirable Fraction = 66.1 Percent

Table 40. VISIT D-2

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.5	3.6-5.4	5.4-7.5	7.8-10.5	10.8-15.3	15.3-21.5	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	100.00	32.00	25.00	17.00	15.00	5.00	2.00	1.00	0.67	200	43	
Overall %	50.1	18.0	12.5	8.5	5.0	3.0	1.0	0.5	0.3			
Cumulative %	50.1	55.1	75.5	57.1	95.2	98.2	98.2	98.7	100.0			
Starch #/T	0.00	0.00	0.00	2.00	2.00	0.00	0.40	0.50	0.00			
% (>5.4 um)				4.7	4.7	0.0	0.5	1.2	0.0			11.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	2.00	25.00	15.00	14.00	5.00	1.60	0.50	0.67			
% (>5.4 um)				35.2	32.5	14.1	3.7	1.2	1.5			55.5
Feed %(>5.4 um)				35.5	37.5	14.1	4.7	2.3	1.5			100.0

Respirable Fraction = 75.5 Percent

Table 41. VISIT D-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.6-5.4	5.4-7.5	7.6-10.5	10.6-15.3	15.3-21.5	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	125.00	35.00	21.00	11.00	5.00	3.50	2.25	1.25	1.00	207	25	
Overall %	60.8	15.5	10.1	5.3	2.5	1.7	1.1	0.5	0.5			
Cumulative %	50.5	77.5	57.5	93.2	96.1	57.5	98.5	55.5	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.50	0.75	0.25	0.25			
% (>5.4 um)				0.0	0.0	2.0	3.0	1.0	1.0			7.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	21.00	11.00	5.50	1.70	2.00	0.00	0.00			
% (>5.4 um)				44.0	22.0	5.5	5.0	0.0	0.0			50.5
Feed %(>5.4 um)				44.0	22.0	5.5	11.0	1.0	1.0			57.5

Respirable Fraction = 57.5 Percent

Table 42. VISIT D-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.5	3.6-5.4	5.4-7.5	7.6-10.5	10.6-15.3	15.3-21.5	21.5-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	105.00	28.00	25.00	15.00	11.00	5.00	3.00	1.25	0.13	196	37	
Overall %	53.5	14.8	12.7	8.1	5.5	3.1	1.5	0.5	0.1			
Cumulative %	53.5	58.2	51.0	58.1	94.7	97.5	55.3	99.8	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.25	0.00			
% (>5.4 um)				0.0	0.0	0.0	1.3	0.7	0.0			2.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.3	0.3			0.7
Grain Meal #/T	0.00	0.00	7.00	15.00	11.00	5.00	2.50	0.55	0.00			
% (>5.4 um)				40.1	25.4	15.1	5.7	2.3	0.0			94.5
Feed %(>5.4 um)				40.1	28.4	15.1	5.0	3.0	0.0			55.7

Respirable Fraction = 51.0 Percent

Table 43. VISIT D-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.5	3.6-5.4	5.4-7.5	7.6-10.5	10.6-15.3	15.3-21.5	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	115.00	44.00	33.00	23.00	21.00	14.00	5.00	2.50	0.50	260	57	
Overall %	44.8	15.5	12.7	5.5	5.1	5.4	2.3	1.0	0.2			
Cumulative %	44.8	51.5	74.2	53.1	81.2	55.5	55.5	99.5	100.0			
Starch #/T	0.00	0.00	0.00	0.00	4.00	4.00	3.00	1.50	0.25			
% (>5.4 um)				0.0	5.0	8.0	4.5	2.2	0.4			15.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	2.00	23.00	17.00	10.00	3.00	1.00	0.25			
% (>5.4 um)				34.3	25.4	14.5	4.5	1.5	0.4			81.0
Feed %(>5.4 um)				34.3	31.3	20.5	5.0	3.7	0.7			100.0

Respirable Fraction = 74.2 Percent

Table 44.

VISIT D-6

SIZE CLASSES, MICRONS

VARIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	103.00	24.00	23.00	20.00	11.00	9.50	6.00	1.44	0.00	197	47	
Overall %	52.3	12.2	11.7	10.2	5.6	4.8	3.0	0.7	0.0			
Cumulative %	52.3	64.5	76.2	86.3	91.9	96.2	99.3	100.0	100.0			
Starch #/T	0.00	0.00	0.00	1.00	0.00	2.00	1.50	0.33	0.00			
% (>5.4 um)				2.1	0.0	4.3	3.2	0.7	0.0			10.3
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.2	0.0			0.2
Grain Meal #/T	0.00	0.00	3.00	16.00	11.00	7.00	1.50	1.11	0.00			
% (>5.4 um)				34.1	23.4	14.9	3.2	2.4	0.0			78.0
Feed %(>5.4 um)				36.2	23.4	19.2	6.4	3.1	0.0			98.3

Respirable Fraction = 76.2 PERCENT

Table 45.

VISIT D-7

SIZE CLASSES, MICRONS

VARIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	104.00	29.00	11.00	16.00	9.00	7.00	4.30	2.00	0.17	182	38	
Overall %	57.0	15.8	6.0	8.8	4.8	3.8	2.4	1.1	0.1			
Cumulative %	57.0	72.9	78.9	87.7	92.6	96.5	98.9	99.9	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.50	0.67	1.67	0.33	0.00			
% (>5.4 um)				0.0	1.3	1.7	4.3	0.9	0.0			9.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.17			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.9	0.4			1.3
Grain Meal #/T	0.00	0.00	0.00	13.00	8.50	4.00	2.67	1.33	0.00			
% (>5.4 um)				33.9	22.1	10.4	6.8	3.5	0.0			76.7
Feed %(>5.4 um)				33.9	23.4	12.1	11.3	4.3	0.0			85.9

Respirable Fraction = 78.9 Percent

Table 46.

VISIT D-8

SIZE CLASSES, MICRONS

V4RIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	104.00	37.00	19.00	10.00	9.00	6.00	5.50	2.17	0.50	191	32	
Overall %	54.4	19.4	9.4	5.2	4.2	3.1	2.9	1.1	0.3			
Cumulative %	54.4	73.8	83.2	88.4	92.6	95.7	98.6	99.7	100.0			
Starch #/T	0.00	0.00	0.00	1.00	0.00	1.00	3.00	0.87	0.00			
% (>5.4 um)				3.1	0.0	3.1	9.3	2.1	0.0			17.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	3.00	9.00	9.00	5.00	2.50	1.50	0.50			
% (>5.4 um)				24.9	24.9	15.5	7.8	4.7	1.8			79.3
Feed %(>5.4 um)				28.0	24.9	19.7	17.1	8.7	1.6			88.9

Respirable Fraction = 93.2 Percent

Table 47.

VISIT E-1

SIZE CLASSES, MICRONS

VARIABLE	<2.7	2.7-3.9	3.6-5.4	5.4-7.8	7.6-10.8	10.6-15.3	15.3-21.6	21.6-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	100.00	15.00	9.50	3.00	2.25	1.70	0.80	0.70	0.10	133	9	
Overall %	75.1	11.3	7.1	2.3	1.7	1.3	0.7	0.5	0.1			
Cumulative %	75.1	86.4	93.5	95.9	97.4	98.7	99.4	99.9	100.0			
Starch #/T	0.00	0.00	0.50	0.00	0.25	0.00	0.40	0.10	0.00			
% (>5.4 um)				0.0	2.9	0.0	4.8	1.2	0.0			8.7
Skin #/T	0.00	0.00	0.00	0.00	0.25	0.17	0.00	0.10	0.00			
% (>5.4 um)				0.0	2.9	2.0	0.0	1.2	0.0			6.0
Grain Meal #/T	0.00	0.00	0.00	1.25	1.50	1.00	0.40	0.40	0.10			
% (>5.4 um)				14.5	17.3	11.6	4.6	4.6	1.2			83.8
Feed %(>5.4 um)				14.5	20.2	11.6	9.2	5.9	1.2			62.6

Respirable Fraction = 93.5 Percent

Table 48. VISIT E-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.6	21.6-30.6	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	110.00	66.00	34.00	25.00	18.00	8.50	8.00	1.25	0.38	242	62	
Overall %	45.4	14.8	14.0	10.6	7.4	3.6	3.3	0.8	0.2			
Cumulative %	45.4	60.3	74.3	84.7	92.1	96.0	99.3	99.8	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.00	1.50	2.00	0.00	0.00			
% (>5.4 um)				1.8	1.8	2.4	3.2	0.0	0.0			8.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.4	0.0			0.4
Grain Meal #/T	0.00	1.00	34.00	24.00	17.00	8.00	5.50	1.00	0.38			
% (>5.4 um)				38.8	27.4	12.8	8.8	1.8	0.8			89.9
Feed %(>5.4 um)				40.2	29.0	18.3	12.1	1.6	0.8			88.8

Respirable Fraction = 74.3 Percent

Table 49. VISIT E-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.8-5.4	5.4-7.6	7.8-10.8	10.8-16.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	155.00	48.00	22.00	17.00	22.00	12.00	3.33	1.10	0.22	282	58	
Overall %	58.0	17.4	7.8	8.0	7.8	4.3	1.2	0.4	0.1			
Cumulative %	55.0	72.4	80.2	88.3	94.1	98.3	99.5	99.8	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.00	2.00	1.00	0.00	0.00			
% (>5.4 um)				1.8	1.8	3.8	1.8	0.0	0.0			8.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.4			0.4
Grain Meal #/T	0.00	0.00	8.00	12.00	21.00	10.00	2.30	1.00	0.00			
% (>5.4 um)				21.8	37.7	18.0	4.1	1.8	0.0			83.2
Feed %(>5.4 um)				23.4	39.6	21.6	5.8	1.6	0.0			82.2

Respirable Fraction = 80.2 Percent

Table 50. VISIT E-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.6	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	117.00	43.00	22.00	11.80	13.80	11.50	2.17	1.10	0.10	222	40	
Overall %	52.7	16.4	8.8	5.2	6.1	5.2	1.0	0.5	0.0			
Cumulative %	52.7	72.1	82.0	87.2	93.3	98.5	99.6	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	2.80	2.00	0.33	0.10	0.00			
% (>5.4 um)				0.0	6.3	8.0	0.8	0.3	0.0			12.4
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	1.6	0.0	0.0	0.0			1.3
Grain Meal #/T	0.00	0.00	3.00	8.00	10.00	6.00	1.80	1.00	0.10			
% (>5.4 um)				22.8	28.1	22.6	4.6	2.5	0.3			77.8
Feed %(>5.4 um)				22.8	51.4	27.8	6.3	2.6	0.3			88.8

Respirable Fraction = 82.0 Percent

Table 51. VISIT E-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.8-5.4	5.4-7.8	7.8-10.8	10.8-16.3	16.3-21.6	21.6-30.6	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	100.00	34.00	20.00	11.00	7.50	7.00	1.70	0.60	0.40	182	28	
Overall %	54.8	18.7	11.0	6.0	4.1	3.8	0.8	0.3	0.2			
Cumulative %	54.8	73.8	84.5	90.8	94.7	98.5	99.5	99.8	100.0			
Starch #/T	0.00	0.00	0.00	0.00	1.00	0.50	0.00	0.00	0.00			
% (>5.4 um)				0.0	3.6	1.8	0.0	0.0	0.0			6.3
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.20	0.20			
% (>5.4 um)				0.0	0.0	0.0	0.8	0.7	0.7			2.0
Grain Meal #/T	0.00	0.00	4.00	8.00	6.00	6.00	1.36	0.40	0.10			
% (>5.4 um)				28.4	21.6	21.3	4.7	1.4	0.4			77.4
Feed %(>5.4 um)				28.4	24.8	23.0	4.7	1.4	0.4			82.7

Respirable Fraction = 84.6 PERCENT

Table 52. VISIT E-7

VARIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.9	10.9-15.3	15.3-21.6	21.6-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	122.00	30.00	22.00	25.00	11.00	9.50	3.75	0.86	0.36	223	49	
Overall %	54.6	13.4	9.9	11.2	4.9	3.5	1.7	0.4	0.2			
Cumulative %	54.6	68.0	77.9	89.0	94.0	97.5	99.2	99.6	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.00	0.50	0.50	0.07	0.00			
% (>5.4 um)				2.0	2.0	1.0	1.0	0.1	0.0			5.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.4			0.4
Grain Meal #/T	0.00	0.00	4.00	14.00	10.00	5.50	2.25	0.64	0.07			
% (>5.4 um)				29.3	20.2	11.1	4.5	1.3	0.1			55.6
Feed %(>5.4 um)				30.3	22.2	12.1	5.6	1.4	0.1			71.6

Respirable Fraction = 77.8 Percent

Table 53. VISIT E-9

VARIABLE	<2.7	2.7-3.5	3.8-5.4	5.4-7.6	7.8-10.9	10.8-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	101.00	20.00	15.00	9.00	10.00	5.00	2.30	1.00	0.10	192	26	
Overall %	52.2	12.3	9.2	4.9	5.2	3.1	1.4	0.5	0.1			
Cumulative %	52.2	74.5	83.7	88.7	94.8	97.9	99.3	99.9	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.50	0.00	1.50	0.10	0.00			
% (>5.4 um)				0.0	1.9	0.0	5.7	0.4	0.0			9.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.4			0.4
Grain Meal #/T	0.00	0.00	5.00	7.00	9.50	5.00	1.67	0.90	0.00			
% (>5.4 um)				25.5	32.2	18.9	6.3	3.4	0.0			97.4
Feed %(>5.4 um)				26.5	34.1	18.9	12.0	3.8	0.0			95.3

Respirable Fraction = 83.7 Percent

Table 54. VISIT F-1

VARIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.8-10.9	10.8-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	51.00	15.00	10.00	1.75	1.75	0.50	0.00	0.25	0.50	81	5	
Overall %	63.2	18.6	12.4	2.2	2.2	0.8	0.0	0.3	0.5			
Cumulative %	63.2	81.7	94.1	96.3	98.5	99.1	99.1	99.4	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.25			
% (>5.4 um)				0.0	10.5	0.0	0.0	0.0	5.3			16.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	4.50	1.50	1.25	0.50	0.00	0.25	0.25			
% (>5.4 um)				31.5	26.3	10.5	0.0	5.3	5.3			78.9
Feed %(>5.4 um)				31.5	38.8	10.5	0.0	5.3	10.5			94.7

Respirable Fraction = 94.1 Percent

Table 55. VISIT F-2

VARIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.8-10.9	10.8-15.3	15.3-21.5	21.5-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	73.00	16.00	11.00	12.00	7.50	9.50	7.00	8.00	0.67	144	44	
Overall %	50.8	11.1	7.7	8.4	5.2	6.9	4.8	5.5	0.5			
Cumulative %	50.8	61.8	69.8	78.0	83.2	89.1	94.0	99.5	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	3.0	0.0			3.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.9	0.0			0.9
Grain Meal #/T	0.00	1.00	2.00	9.00	5.00	5.00	2.50	1.00	0.67			
% (>5.4 um)				20.5	11.4	11.4	5.7	2.3	1.5			53.1
Feed %(>5.4 um)				20.5	11.4	11.4	5.7	5.3	1.5			55.1

Respirable Fraction = 89.5 Percent

Table 56. VISIT F-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	106.00	23.00	20.00	12.00	15.00	7.50	5.50	4.00	0.67	194	45	
Overall %	54.7	11.9	10.3	6.2	7.7	3.9	2.8	2.1	0.3			
Cumulative %	54.7	66.5	76.8	83.1	90.9	94.7	97.5	99.7	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.50	1.00	2.50	3.00	0.00			
% (>5.4 um)				0.0	1.1	2.2	5.8	8.7	0.0			15.7
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	1.1	0.0	0.0			1.1
Grain Meal #/T	0.00	0.00	7.00	10.00	13.00	6.50	2.50	1.00	0.67			
% (>5.4 um)				22.4	25.1	14.8	5.8	2.2	1.5			75.4
Feed %(>5.4 um)				22.4	30.2	19.8	11.2	8.0	1.5			91.0

Respirable Fraction = 79.8 Percent

Table 57. VISIT F-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	57.00	30.00	11.50	4.87	5.87	4.87	1.80	0.20	0.80	116	19	
Overall %	49.0	25.8	9.9	4.0	4.9	4.0	1.5	0.2	0.7			
Cumulative %	49.0	74.8	84.7	88.7	93.8	97.8	99.1	99.3	100.0			
Starch #/T	0.00	0.00	0.00	0.33	0.86	1.33	0.40	0.00	0.80			
% (>5.4 um)				1.9	3.7	7.5	2.2	0.0	3.4			16.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	2.2	0.0	0.0			2.2
Grain Meal #/T	0.00	0.00	0.00	0.00	0.33	1.86	0.90	0.20	0.00			
% (>5.4 um)				0.0	1.5	9.3	4.5	1.1	0.0			18.9
Feed %(>5.4 um)				1.9	5.8	18.8	8.7	1.1	3.4			35.4

Respirable Fraction = 94.7 Percent

Table 58. VISIT F-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	75.00	21.00	18.00	12.00	9.00	3.25	1.43	1.11	0.22	139	24	
Overall %	54.3	15.2	13.0	8.7	6.3	2.4	1.0	0.8	0.2			
Cumulative %	54.3	69.6	82.6	91.3	95.8	98.0	99.0	99.8	100.0			
Starch #/T	0.00	0.00	0.00	1.00	0.50	0.00	0.57	0.88	0.11			
% (>5.4 um)				4.2	2.1	0.0	2.4	2.7	0.5			11.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.00	0.00	1.00	2.00	0.71	0.88	0.11			
% (>5.4 um)				0.0	4.2	9.3	3.0	2.7	0.5			19.7
Feed %(>5.4 um)				4.2	9.2	9.3	9.3	5.5	0.9			30.5

Respirable Fraction = 92.8 Percent

Table 59. VISIT F-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	100.00	28.00	18.00	10.00	9.50	4.87	2.75	1.25	0.13	171	25	
Overall %	58.4	16.3	10.5	5.8	3.8	2.7	1.8	0.7	0.1			
Cumulative %	99.4	74.7	85.2	91.1	94.8	97.8	99.2	99.8	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.50	3.00	0.50	0.38	0.00			
% (>5.4 um)				4.0	5.8	11.8	2.0	1.5	0.0			25.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.4	0.0			0.4
Grain Meal #/T	0.00	0.00	0.00	1.00	1.00	1.87	1.75	0.75	0.10			
% (>5.4 um)				4.0	4.0	8.8	5.8	3.0	0.4			24.8
Feed %(>5.4 um)				7.9	9.9	18.5	9.8	4.4	0.4			50.0

Respirable Fraction = 85.2 PERCENT

Table 60. VISIT F-7

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	150.00	26.00	18.00	23.00	12.00	7.33	2.75	0.00	0.00	242	45	
Overall %	62.0	12.0	7.4	9.5	5.0	3.0	1.1	0.0	0.0			
Cumulative %	62.0	73.9	81.4	90.6	95.8	98.8	100.0	100.0	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.00	3.00	0.25	0.00	0.00			
% (>5.4 um)				2.2	2.2	6.7	0.6	0.0	0.0			11.6
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.8	0.8	0.0			1.1
Grain Meal #/T	0.00	0.00	0.00	12.00	6.00	6.00	2.00	0.00	0.00			
% (>5.4 um)				28.6	17.7	11.1	4.4	0.0	0.0			56.6
Feed %(>5.4 um)				26.8	20.0	17.7	6.0	0.0	0.0			71.5

Respirable Fraction = 61.4 Percent

Table 61. VISIT F-8

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.8-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	66.00	33.00	27.00	16.00	11.00	5.67	1.37	0.10	0.00	183	37	
Overall %	47.0	16.0	14.7	10.4	8.0	3.1	0.7	0.1	0.0			
Cumulative %	47.0	65.0	79.7	90.1	98.1	98.2	98.8	100.0	100.0			
Starch #/T	0.00	0.00	0.00	1.00	1.00	0.00	0.13	1.00	0.00			
% (>5.4 um)				2.7	2.7	0.0	0.3	2.7	0.0			8.4
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	4.00	11.00	10.00	5.60	1.25	0.13	0.00			
% (>5.4 um)				26.5	25.9	15.1	3.4	0.3	0.0			75.3
Feed %(>5.4 um)				32.3	26.6	16.1	3.7	3.0	0.0			63.7

Respirable Fraction = 76.7 Percent

Table 62. VISIT G-1

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	101.00	12.00	10.00	6.00	5.50	5.50	2.75	2.50	0.00	146	23	
Overall %	69.1	8.2	6.8	4.1	4.4	3.8	1.8	1.7	0.0			
Cumulative	69.1	77.3	84.1	88.2	92.6	96.4	98.3	100.0	100.0			
Starch #/T	0.00	0.00	1.00	0.00	1.50	2.00	0.75	1.00	0.00			
% (>5.4 um				0.0	6.5	6.6	3.2	4.3	0.0			22.6
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	4.00	5.60	5.00	3.00	2.00	1.50	0.00			
% (>5.4 um				23.7	21.5	12.6	8.6	6.5	0.0			73.1
Feed %(>5.4 um				23.7	26.0	21.6	11.8	10.6	0.0			65.7

Respirable Fraction = 84.1 Percent

Table 63. VISIT G-2

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	106.00	14.00	13.00	6.60	3.30	3.66	1.33	0.65	0.23	146	16	
Overall %	71.2	9.4	8.7	4.4	2.2	2.5	0.8	0.6	0.2			
Cumulative	71.2	80.8	89.3	93.7	95.8	98.4	99.3	99.8	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.33	0.67	0.11	0.15	0.00			
% (>5.4 um				0.0	2.1	4.2	0.7	0.6	0.0			7.6
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	2.00	8.00	2.67	3.00	1.10	0.63	0.23			
% (>5.4 um				37.8	18.8	16.6	6.6	3.3	1.4			65.3
Feed %(>5.4 um				37.6	16.8	23.1	7.6	4.3	1.4			63.2

Respirable Fraction = 66.3 Percent

Table 64. VISIT G-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	101.00	33.00	25.00	28.00	24.00	11.00	7.00	2.50	0.75	230	71	
Overall %	43.9	14.3	10.9	11.3	10.4	4.8	3.0	1.1	0.3			
Cumulative	43.9	58.2	69.1	80.3	90.8	95.5	98.5	99.7	100.0			
Starch #/T	0.00	0.00	0.00	0.00	2.00	1.00	1.50	0.25	0.00			
% (>5.4 um				0.0	2.9	1.4	2.1	0.4	0.0			6.7
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50			
% (>5.4 um				0.0	0.0	0.0	0.7	0.0	0.7			1.4
Grain Meal #/T	0.00	0.00	24.00	28.00	22.00	10.00	5.00	2.25	0.25			
% (>5.4 um				38.5	30.8	14.0	7.0	3.2	0.4			81.9
Feed %(>5.4 um				38.5	33.7	15.4	8.1	3.5	0.4			82.9

Respirable Fraction = 69.1 Percent

Table 65. VISIT G-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	105.00	18.00	11.00	11.00	15.00	10.00	7.00	2.20	1.00	180	46	
Overall %	58.3	10.0	6.1	6.1	8.3	5.5	3.9	1.2	0.8			
Cumulative	58.3	68.3	74.4	80.5	88.8	94.3	98.2	99.4	100.0			
Starch #/T	0.00	0.00	0.00	0.00	2.00	1.00	2.00	0.60	0.20			
% (>5.4 um				0.0	4.3	2.2	4.3	1.7	0.4			13.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20			
% (>5.4 um				0.0	0.0	0.0	0.0	0.4	0.4			0.8
Grain Meal #/T	0.00	0.00	0.00	11.00	13.00	8.00	5.00	1.20	0.80			
% (>5.4 um				23.8	28.1	18.5	10.8	2.8	1.3			88.1
Feed %(>5.4 um				23.8	32.5	21.8	15.2	4.3	1.7			99.1

Respirable Fraction = 74.4 Percent

Table 66. VISIT G-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.5	7.5-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	114.00	14.00	12.00	13.00	5.00	5.00	5.00	2.50	0.00	171	31	
Overall %	66.9	8.2	7.0	7.6	2.9	2.5	2.9	1.5	0.0			
Cumulative	66.9	75.1	82.1	89.7	92.7	95.5	98.5	100.0	100.0			
Starch #/T	0.00	0.00	0.00	1.00	0.00	3.50	2.00	1.00	0.00			
% (>5.4 um				3.3	0.0	11.5	6.5	5.2	0.0			26.6
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.00	10.00	5.00	1.50	3.00	0.40	0.00			
% (>5.4 um				32.8	15.4	4.6	9.6	1.3	0.0			55.2
Feed %(>5.4 um				36.1	18.4	15.4	18.4	6.6	0.0			81.6

Respirable Fraction = 82.1 Percent

Table 67. VISIT G-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	100.00	30.00	27.00	21.00	22.00	17.00	3.30	1.50	0.13	222	85	
Overall %	45.1	13.5	12.2	9.5	9.5	7.7	1.5	0.7	0.1			
Cumulative	45.1	58.6	70.7	80.2	90.1	97.8	99.3	99.9	100.0			
Starch #/T	0.00	0.00	0.00	1.00	5.00	4.00	1.67	0.38	0.00			
% (>5.4 um				1.9	7.7	8.2	2.8	0.8	0.0			18.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.13			
% (>5.4 um				0.0	0.0	0.0	0.0	0.2	0.2			0.4
Grain Meal #/T	0.00	0.00	5.00	20.00	17.00	13.00	1.67	1.00	0.00			
% (>5.4 um				30.8	26.2	20.0	2.8	1.5	0.0			81.1
Feed %(>5.4 um				32.3	33.8	28.2	5.1	2.1	0.0			99.7

Respirable Fraction = 70.7 PERCENT

Table 68. VISIT G-7

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	105.00	35.00	23.00	15.00	12.00	3.00	1.14	0.14	0.00	195	31	
Overall %	54.3	17.8	11.8	7.7	6.1	1.5	0.6	0.1	0.0			
Cumulative	54.3	72.2	84.0	91.7	97.8	99.3	99.8	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.25	0.14	0.00	0.00			
% (>5.4 um				0.0	0.0	0.5	0.4	0.0	0.0			1.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	3.00	11.00	10.00	2.50	1.00	0.14	0.00			
% (>5.4 um				35.2	32.0	8.0	3.2	0.4	0.0			78.8
Feed %(>5.4 um				35.2	32.0	8.0	3.8	0.4	0.0			80.0

Respirable Fraction = 84.0 Percent

Table 69. VISIT G-8

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.5	7.5-10.5	10.5-15.3	15.3-21.5	21.5-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	103.00	15.00	10.00	5.50	8.50	10.00	2.75	1.00	0.00	158	25	
Overall %	65.3	12.0	8.3	3.5	4.1	8.3	1.7	0.8	0.0			
Cumulative	65.3	77.3	83.7	87.2	91.3	97.8	98.4	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	2.50	0.50	0.00	0.00			
% (>5.4 um				0.0	0.0	8.7	1.9	0.0	0.0			11.7
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00			
% (>5.4 um				0.0	0.0	0.0	0.0	0.8	0.0			0.8
Grain Meal #/T	0.00	0.00	1.00	5.50	5.50	8.50	2.25	0.80	0.00			
% (>5.4 um				21.4	21.4	25.2	5.7	3.1	0.0			78.8
Feed %(>5.4 um				21.4	21.4	35.0	10.7	3.1	0.0			81.5

Respirable Fraction = 83.7 Percent

Table 70. VISIT H-1

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	183.00	18.00	13.00	13.00	1.40	0.50	0.80	0.00	0.00	211	15	
Overall %	77.3	8.0	8.2	8.2	0.7	0.3	.0.4	0.0	0.0			
Cumulative %	77.3	88.3	92.5	98.7	99.3	99.8	100.0	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	1.3	0.0	0.0	0.0	0.0			1.3
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	11.00	13.00	1.20	0.80	0.80	0.00	0.00			
% (>5.4 um)				82.3	7.8	3.8	5.1	0.0	0.0			88.7
Feed %(>5.4 um)				82.3	8.9	3.8	5.1	0.0	0.0			100.0

Respirable Fraction = 92.5 Percent

Table 71. VISIT H-2

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.5	10.8-15.3	15.3-21.5	21.8-30.8	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	48.00	10.00	5.00	1.80	1.20	0.40	0.80	0.00	0.40	55	4	
Overall %	70.3	15.3	7.8	2.8	1.8	0.8	0.8	0.0	0.8			
Cumulative %	70.3	85.8	93.3	96.0	97.8	98.5	99.4	98.4	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	3.50	1.50	1.20	0.40	0.50	0.00	0.40			
% (>5.4 um)				40.5	27.3	9.1	13.8	0.0	9.1			100.0
Feed %(>5.4 um)				40.5	27.3	9.1	13.8	0.0	9.1			100.0

Respirable Fraction = 93.3 Percent

Table 72. VISIT H-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	81.00	14.00	6.50	4.00	3.25	2.00	0.50	0.20	0.00	114	10	
Overall %	71.3	12.3	7.8	3.5	2.8	1.8	0.5	0.2	0.0			
Cumulative %	71.3	83.7	91.1	94.7	97.5	99.3	99.8	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.20	0.00			
% (>5.4 um)				0.0	0.0	0.0	4.0	2.0	0.0			8.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.50	3.33	3.00	1.80	0.20	0.00	0.00			
% (>5.4 um)				33.1	29.8	17.9	2.0	0.0	0.0			82.8
Feed %(>5.4 um)				33.1	29.8	17.9	8.0	2.0	0.0			90.8

Respirable Fraction = 91.1 Percent

Table 73. VISIT H-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	100.00	21.00	16.00	10.00	6.00	5.00	3.25	1.67	0.33	166	26	
Overall %	60.2	12.6	11.4	6.0	3.6	3.0	2.0	1.0	0.2			
Cumulative %	60.2	72.8	84.2	90.2	93.8	96.8	98.8	99.8	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.17			
% (>5.4 um)				0.0	0.0	0.0	1.5	0.0	0.6			2.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	2.00	10.00	6.00	5.00	2.75	1.67	0.17			
% (>5.4 um)				38.1	22.8	19.0	10.5	6.4	0.6			97.5
Feed %(>5.4 um)				38.1	22.8	19.0	12.4	6.4	1.3			100.0

Respirable Fraction = 84.2 Percent

Table 74. VISIT H-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	164.00	17.00	11.00	8.50	10.50	13.00	8.00	2.75	0.50	234	42	
Overall %	70.0	7.3	4.7	4.1	4.5	5.6	2.6	1.2	0.2			
Cumulative %	70.0	77.3	82.0	86.0	90.5	96.1	98.8	99.6	100.0			
Starch #/T	0.00	0.00	1.00	0.50	1.80	2.60	3.00	1.25	0.25			
% (>5.4 um)				1.2	3.6	5.6	7.1	3.0	0.6			21.3
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	2.00	8.00	8.00	8.50	3.00	1.50	0.25			
% (>5.4 um)				21.3	21.3	13.0	7.1	3.6	0.6			66.6
Feed %(>5.4 um)				22.8	24.8	18.6	14.2	6.8	1.2			88.2

Respirable Fraction = 82.0 Percent

Table 75. VISIT H-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	101.00	22.00	14.00	12.00	6.80	6.50	2.00	1.60	0.00	166	26	
Overall %	60.7	13.2	8.4	7.2	4.1	3.9	1.2	0.8	0.0			
Cumulative %	60.7	74.0	82.4	89.6	94.7	98.6	99.8	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	1.60	3.00	0.67	0.00	0.00			
% (>5.4 um)				0.0	4.1	10.2	2.3	0.0	0.0			17.6
Skin #/T	0.00	0.00	0.00	0.00	0.50	0.50	0.00	0.13	0.00			
% (>5.4 um)				0.0	1.7	1.7	0.0	0.4	0.0			3.8
Grain Meal #/T	0.00	0.00	8.00	12.00	7.60	2.00	1.00	0.25	0.00			
% (>5.4 um)				41.0	25.5	6.8	3.4	0.8	0.0			77.6
Feed %(>5.4 um)				41.0	30.7	17.1	8.7	0.8	0.0			65.3

Respirable Fraction = 82.4 PERCENT

Table 76.

VISIT H-7

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	35.00	18.00	17.00	13.00	12.00	11.00	3.00	1.00	0.20	108	40	
Overall %	32.3	14.8	15.7	12.0	11.1	10.2	2.8	0.8	0.2			
Cumulative %	32.3	47.1	62.6	74.5	86.0	96.1	98.8	98.8	100.0			
Starch #/T	0.00	0.00	0.00	0.00	1.00	2.00	0.00	0.20	0.20			
% (>5.4 um)				0.0	2.5	5.0	0.0	0.5	0.5			8.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	5.00	11.00	11.00	5.00	2.50	0.80	0.00			
% (>5.4 um)				27.4	27.4	22.4	5.2	2.0	0.0			85.3
Feed %(>5.4 um)				27.4	28.8	27.4	8.2	2.5	0.5			93.8

Respirable Fraction = 82.8 Percent

Table 77.

VISIT H-8

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	102.00	23.00	14.00	12.00	10.00	7.00	2.50	0.35	0.05	171	32	
Overall %	59.7	13.8	8.2	7.0	5.8	4.1	1.5	0.2	0.0			
Cumulative %	59.7	73.1	81.3	88.4	94.2	98.5	98.5	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.00	2.00	0.50	0.00	0.00			
% (>5.4 um)				0.0	0.0	5.3	1.8	0.0	0.0			7.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.2	0.0			0.2
Grain Meal #/T	0.00	0.00	14.00	12.00	10.00	5.00	2.00	0.30	0.05			
% (>5.4 um)				37.8	31.3	15.7	5.3	0.8	0.2			52.0
Feed %(>5.4 um)				37.8	31.3	21.8	7.8	0.5	0.2			99.8

Respirable Fraction = 81.3 Percent

Table 78.

VISIT I-1

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	115.00	22.00	20.00	18.00	10.00	8.00	4.87	2.00	1.20	201	44	
Overall %	57.3	11.0	10.0	9.0	5.0	4.0	2.3	1.0	0.8			
Cumulative %	57.3	88.2	78.2	87.1	92.1	96.1	98.4	99.4	100.0			
Starch #/T	0.00	0.00	0.00	2.00	0.00	3.00	2.00	1.80	0.20			
% (>5.4 um)				4.8	0.0	8.8	4.8	3.8	0.5			20.1
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	1.4			1.4
Grain Meal #/T	0.00	0.00	8.00	15.00	10.00	5.00	2.87	0.20	0.40			
% (>5.4 um)				34.2	22.8	11.4	8.1	0.5	0.8			75.8
Feed %(>5.4 um)				38.8	22.8	18.2	10.8	4.1	1.4			85.8

Respirable Fraction = 78.2 Percent

Table 79.

VISIT I-2

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	107.00	31.00	25.00	28.00	12.00	12.00	5.50	2.20	0.50	221	58	
Overall %	48.4	14.0	11.3	11.7	5.4	5.4	2.8	1.0	0.3			
Cumulative %	48.4	82.4	73.7	85.4	90.8	96.2	98.7	99.7	100.0			
Starch #/T	0.00	0.00	0.00	1.00	0.00	2.00	1.00	0.40	0.20			
% (>5.4 um)				1.7	0.0	3.4	1.7	0.7	0.3			7.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.3	0.3			0.7
Grain Meal #/T	0.00	2.00	14.00	25.00	12.00	10.00	4.50	1.60	0.20			
% (>5.4 um)				42.9	20.8	17.2	7.7	2.7	0.3			81.4
Feed %(>5.4 um)				44.8	20.8	20.5	8.4	3.4	0.7			98.3

Respirable Fraction = 73.7 Percent

Table 80. VISIT I-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
S/Traverse	114.00	34.00	22.00	15.00	17.00	8.80	4.00	1.40	0.80	214	44	
Overall %	53.4	15.8	10.3	7.0	8.0	2.8	1.8	0.7	0.3			
Cumulative %	53.4	69.3	79.8	86.7	94.8	97.2	99.1	99.7	100.0			
Starch S/T	0.00	0.00	0.00	0.00	2.00	0.50	1.30	0.40	0.14			
% (>5.4 um)				0.0	4.8	1.1	3.0	0.8	0.3			10.0
Skin S/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.3	0.3			0.8
Grain Meal S/T	0.00	1.00	10.00	10.00	10.00	8.00	2.70	0.71	0.29			
% (>5.4 um)				34.5	23.0	11.5	8.2	1.8	0.7			77.5
Feed %(>5.4 um)				34.5	27.8	12.8	8.2	2.8	1.0			87.4

Respirable Fraction = 79.8 Percent

Table 81. VISIT I-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
S/Traverse	98.00	38.00	37.00	30.00	12.00	10.00	4.70	1.10	0.20	230	58	
Overall %	43.0	15.7	16.1	13.0	5.2	4.3	2.0	0.5	0.1			
Cumulative %	43.0	58.7	74.8	87.8	93.0	97.4	99.4	99.9	100.0			
Starch S/T	0.00	0.00	0.00	0.00	1.00	1.00	1.00	0.33	0.00			
% (>5.4 um)				0.0	1.7	1.7	1.7	0.8	0.0			5.7
Skin S/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.22			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.4	0.4			0.8
Grain Meal S/T	0.00	0.00	25.00	28.00	11.00	8.00	2.00	0.87	0.00			
% (>5.4 um)				50.0	19.0	15.5	3.4	1.2	0.0			88.1
Feed %(>5.4 um)				50.0	20.7	17.2	5.2	1.7	0.0			94.9

Respirable Fraction = 74.8 Percent

Table 82. VISIT I-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-18.3	18.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
S/Traverse	82.00	20.00	17.00	15.00	21.00	12.00	7.00	1.70	0.80	176	57	
Overall %	48.8	11.4	9.8	8.5	11.8	6.8	4.0	1.0	0.3			
Cumulative %	48.5	87.9	97.5	78.0	88.0	94.8	98.8	99.7	100.0			
Starch S/T	0.00	0.00	0.00	1.00	7.00	4.00	4.00	0.87	0.17			
% (>5.4 um)				1.7	12.2	7.0	7.0	1.2	0.3			28.4
Skin S/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.8			0.8
Grain Meal S/T	0.00	0.00	13.00	14.00	14.00	8.00	3.00	1.00	0.00			
% (>5.4 um)				24.5	24.5	14.0	8.2	1.7	0.0			88.8
Feed %(>5.4 um)				28.2	36.7	21.0	12.2	2.8	0.3			98.4

Respirable Fraction = 67.5 Percent

Table 83. VISIT I-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
S/Traverse	110.00	40.00	22.00	18.00	10.00	5.00	3.30	1.10	0.33	210	38	
Overall %	52.4	19.1	10.5	8.8	4.8	2.4	1.8	0.8	0.2			
Cumulative %	52.4	71.8	82.0	90.8	95.4	97.7	99.3	99.9	100.0			
Starch S/T	0.00	0.00	0.00	0.00	1.00	0.50	0.00	0.00	0.00			
% (>5.4 um)				0.0	2.7	1.3	0.0	0.0	0.0			4.0
Skin S/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.8			0.8
Grain Meal S/T	0.00	0.00	10.00	10.00	9.00	4.50	3.30	1.10	0.11			
% (>5.4 um)				47.7	23.8	11.8	8.7	2.8	0.3			95.4
Feed %(>5.4 um)				47.7	28.5	13.3	9.7	2.8	0.3			99.4

Respirable Fraction = 82.0 PERCENT

Table 84. VISIT I-7

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.8	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	106.00	27.00	11.00	10.00	2.40	2.00	1.60	0.67	0.42	150	17	
Overall %	65.5	16.8	6.6	6.2	1.5	1.2	1.1	0.4	0.6			
Cumulative %	65.5	82.4	88.2	95.6	98.6	98.2	96.3	88.7	100.0			
Starch #/T	0.00	0.00	0.00	0.00	0.40	1.60	0.00	0.25	0.00			
% (>5.4 um)				0.0	2.3	6.7	0.0	1.4	0.0			12.4
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.25			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.5	1.4			2.4
Grain Meal #/T	0.00	0.00	0.00	2.00	0.20	0.33	0.66	0.25	0.08			
% (>5.4 um)				11.6	1.2	1.6	1.5	1.4	0.5			15.4
Feed %(>5.4 um)				11.6	3.6	10.6	1.6	2.6	0.6			30.6

Respirable Fraction = 88.2 Percent

Table 85. VISIT I-8

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.5	3.6-5.4	5.4-7.5	7.6-10.6	10.6-15.3	15.3-21.5	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	104.00	25.00	16.00	16.00	17.00	5.00	6.50	1.40	0.28	194	46	
Overall %	53.5	13.4	8.6	8.3	8.6	3.1	1.5	0.7	0.1			
Cumulative %	66.6	66.6	76.2	85.6	94.2	97.3	98.1	98.6	100.0			
Starch #/T	0.00	0.00	0.00	0.00	4.00	1.50	1.25	0.42	0.00			
% (>5.4 um)				0.0	5.7	3.2	2.7	0.6	0.0			16.6
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.28			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.6	0.6			0.5
Grain Meal #/T	0.00	0.00	10.00	16.00	13.00	4.50	2.25	0.71	0.00			
% (>5.4 um)				66.0	28.2	5.7	4.6	1.5	0.0			83.6
Feed %(>5.4 um)				39.0	36.6	13.0	7.6	2.4	0.0			98.8

Respirable Fraction = 75.2 Percent

Table 86. VISIT J-1

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.5	21.6-30.6	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	67.00	15.00	12.00	6.00	4.50	6.00	5.50	3.67	0.00	116	26	
Overall %	45.3	16.4	10.4	6.6	3.6	6.2	4.6	6.2	0.0			
Cumulative %	45.3	55.7	75.1	66.0	66.6	52.1	66.6	100.0	100.0			
Starch #/T	0.00	0.00	3.00	1.00	1.00	2.00	1.50	1.66	0.00			
% (>5.4 um)				6.6	3.6	7.2	6.4	6.0	0.0			25.6
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>6.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.00	0.00	0.00	1.50	2.50	1.00	0.00			
% (>6.4 um)				0.0	0.0	6.4	6.0	6.6	0.0			18.1
Feed %(>5.4 um)				6.6	6.6	12.6	14.6	6.6	0.0			43.6

Respirable Fraction = 76.1 Percent

Table 87. VISIT J-2

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.6	10.6-16.6	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >6.4	AVG % >5.4
#/Traverse	61.00	10.00	17.00	5.00	7.00	2.00	1.70	1.70	0.00	75	17	
Overall %	41.1	13.3	22.5	5.5	6.6	2.7	2.6	2.6	0.0			
Cumulative %	41.1	84.4	76.6	83.6	62.6	95.5	97.7	100.0	100.0			
Starch #/T	0.00	0.00	0.00	1.00	2.00	0.33	0.50	0.25	0.00			
% (>5.4 um)				6.7	11.5	1.5	2.6	1.4	0.0			23.4
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	1.4			1.4
Grain Meal #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.26	0.75			
% (>6.4 um)				0.0	0.0	0.0	3.6	1.4	4.3			8.5
Feed %(>5.4 um)				5.7	11.5	1.6	6.7	2.6	4.3			63.0

Respirable Fraction = 76.6 Percent

Table 88.

VISIT J-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.8	10.8-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	67.00	24.00	16.00	18.00	11.00	10.00	14.00	12.00	0.00	171	62	
Overall %	38.2	14.0	10.8	6.6	6.4	5.6	8.2	7.0	0.0			
Cumulative %	36.2	53.2	63.7	72.5	78.8	84.6	93.0	100.0	100.0			
Starch #/T	0.00	0.00	0.00	2.00	2.00	6.00	10.00	8.00	0.00			
% (>5.4 um)				3.2	3.2	6.1	16.1	14.8	0.0			46.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.00	0.00	1.00	2.00	4.00	3.00	0.00			
% (>5.4 um)				0.0	1.8	3.2	6.5	4.8	0.0			16.1
Feed %(>5.4 um)				3.2	4.6	11.3	22.8	16.4	0.0			61.3

Respirable Fraction = 63.7 Percent

Table 89.

VISIT J-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.8	7.6-10.8	10.6-15.3	15.3-21.6	21.6-30.8	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	78.00	35.00	16.00	18.00	15.00	17.00	11.00	11.00	0.00	200	66	
Overall %	38.0	17.5	8.0	7.8	7.5	8.5	5.5	8.5	0.0			
Cumulative %	36.0	56.5	65.5	73.0	80.5	89.0	94.5	100.0	100.0			
Starch #/T	0.00	0.00	0.00	3.00	6.00	11.00	3.00	0.75	0.00			
% (>5.4 um)				4.3	8.7	15.6	4.3	1.1	0.0			34.4
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.00	0.00	0.00	1.00	1.80	1.50	0.00			
% (>5.4 um)				0.0	0.0	1.4	2.2	2.2	0.0			5.6
Feed %(>5.4 um)				4.3	8.7	17.4	6.5	3.3	0.0			40.2

Respirable Fraction = 55.8 Percent

Table 90.

VISIT J-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.6	7.6-10.8	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	136.00	54.00	36.00	25.00	16.00	11.00	3.30	3.30	0.00	287	82	
Overall %	47.1	18.6	12.6	8.7	5.6	3.8	1.2	1.2	0.0			
Cumulative %	47.1	65.6	78.5	87.2	93.8	97.7	98.6	100.0	100.0			
Starch #/T	0.00	0.00	1.00	2.00	6.00	3.00	3.00	2.00	0.00			
% (>5.4 um)				3.2	13.0	4.6	4.6	3.2	0.0			28.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	0.00	1.00	0.00	3.00	0.33	1.00	0.00			
% (>5.4 um)				1.6	0.0	4.6	0.5	1.6	0.0			8.7
Feed %(>5.4 um)				4.6	13.0	8.7	8.4	4.6	0.0			37.6

Respirable Fraction = 76.5 Percent

Table 91.

VISIT J-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.6-5.4	5.4-7.5	7.6-10.6	10.6-15.3	15.3-21.8	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	75.00	47.00	34.00	16.00	16.00	8.00	3.30	3.70	0.00	209	83	
Overall %	35.8	22.8	16.3	6.6	6.1	4.3	1.6	1.6	0.0			
Cumulative %	35.6	98.4	74.6	83.3	92.3	66.7	98.2	100.0	100.0			
Starch #/T	0.00	0.00	2.00	3.00	6.00	3.00	1.00	0.33	0.00			
% (>5.4 um)				6.7	6.4	5.7	1.6	0.6	0.0			23.3
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	3.1			3.1
Grain Meal #/T	0.00	0.00	0.00	0.00	0.00	1.00	0.33	1.33	0.00			
% (>5.4 um)				0.0	0.0	1.6	0.8	2.5	0.0			5.0
Feed %(>5.4 um)				8.7	6.4	7.8	2.8	3.1	0.0			28.3

Respirable Fraction = 74.6 PERCENT

Table 92. VISIT J-7

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	57.00	36.00	41.00	31.00	20.00	15.00	12.00	5.00	0.00	216	53	
Overall %	26.0	17.4	18.7	14.2	9.1	6.6	5.5	2.3	0.0			
Cumulative %	26.0	43.4	62.1	76.3	85.4	92.2	97.7	100.0	100.0			
Starch #/T	0.00	0.00	5.00	8.00	6.00	5.00	5.00	2.00	0.00			
% (>5.4 um)				6.6	7.2	7.2	6.0	2.4	0.0			32.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	1.2	0.0			1.2
Grain Meal #/T	0.00	0.00	0.00	0.00	4.00	3.00	4.00	1.50	0.00			
% (>5.4 um)				0.0	4.8	3.6	4.8	1.8	0.0			15.1
Feed %(>5.4 um)				5.6	12.0	10.8	10.8	4.2	0.0			47.6

Respirable Fraction = 62.1 Percent

Table 93. VISIT J-8

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.8-5.4	5.4-7.5	7.6-10.6	10.6-15.3	15.3-21.5	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	69.00	38.00	26.00	18.00	14.00	6.00	4.30	2.20	0.00	211	48	
Overall %	47.0	16.1	13.3	7.6	5.7	4.3	2.0	1.0	0.0			
Cumulative %	47.0	65.1	78.4	86.0	92.6	96.6	98.0	100.0	100.0			
Starch #/T	0.00	1.00	0.00	1.00	2.50	2.00	0.68	0.50	0.00			
% (>5.4 um)				2.2	5.5	4.4	1.5	1.1	0.0			14.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	1.1	0.0			1.1
Grain Meal #/T	0.00	0.00	0.00	0.00	0.00	2.00	1.96	1.50	0.00			
% (>5.4 um)				0.0	0.0	4.4	3.6	3.3	0.0			11.3
Feed %(>5.4 um)				2.2	5.5	6.6	5.1	4.4	0.0			26.0

Respirable Fraction = 78.4 Percent

Table 94. VISIT K-1

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.6	3.8-5.4	5.4-7.6	7.6-10.6	10.6-16.3	15.3-21.8	21.8-30.5	>30	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	101.00	33.00	20.00	13.00	10.00	4.30	1.60	1.40	0.70	185	31	
Overall %	54.6	17.6	10.6	7.0	5.4	2.3	0.6	0.6	0.4			
Cumulative %	54.6	72.4	83.2	90.3	95.7	98.0	98.8	99.6	100.0			
Starch #/T	0.00	0.00	1.00	2.00	3.00	2.00	0.83	0.71	0.26			
% (>5.4 um)				6.5	8.7	5.5	2.7	2.3	0.8			26.5
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.5			0.5
Grain Meal #/T	0.00	0.00	15.00	6.00	7.00	2.30	1.00	0.71	0.26			
% (>5.4 um)				26.0	22.6	7.4	3.2	2.3	0.8			65.5
Feed %(>5.4 um)				35.5	32.3	13.5	5.6	4.6	1.6			53.8

Respirable Fraction = 83.2 Percent

Table 95. VISIT K-2

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.5	3.8-5.4	5.4-7.6	7.6-10.6	10.6-15.3	15.3-21.6	21.6-30.5	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	127.00	20.00	14.00	10.00	2.75	2.13	0.60	0.70	0.20	176	17	
Overall %	71.5	11.3	7.6	5.6	1.6	1.2	0.6	0.4	0.1			
Cumulative %	71.5	82.6	90.7	96.3	97.8	99.0	99.6	99.8	100.0			
Starch #/T	0.00	0.00	0.00	1.00	0.00	0.00	0.20	0.20	0.10			
% (>5.4 um)				6.0	0.0	0.0	1.2	1.2	0.6			6.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.6	0.6	0.0			1.2
Grain Meal #/T	0.00	0.00	11.00	6.00	2.75	2.13	0.50	0.40	0.10			
% (>5.4 um)				54.3	16.6	12.6	3.0	2.4	0.6			89.7
Feed %(>5.4 um)				50.3	16.6	12.5	4.2	3.6	1.2			96.6

Respirable Fraction = 90.7 Percent

Table 96. VISIT K-3

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.8	>30.	TOTAL All	TOTAL >5.4	AVG % >5.4
#/Traverse	108.00	24.00	20.00	12.00	10.00	14.00	11.00	3.70	0.00	209	97	
Overall %	51.7	11.8	9.8	5.2	7.2	6.7	5.3	1.8	0.0			
Cumulative %	51.7	63.2	72.8	78.1	85.2	93.0	98.2	100.0	100.0			
Starch #/T	0.00	0.00	0.00	0.00	2.00	2.00	4.00	2.30	0.00			
% (>5.4 um)				0.0	3.5	3.8	7.1	4.1	0.0			16.2
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	1.00	20.00	12.00	13.00	12.00	7.00	1.30	0.00			
% (>5.4 um)				22.8	22.8	21.2	12.3	2.3	0.0			81.7
Feed %(>5.4 um)				22.8	26.5	24.7	16.4	8.3	0.0			98.8

Respirable Fraction = 72.8 Percent

Table 97. VISIT K-4

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.8	>30.	TOTAL All	TOTAL >8.4	AVG % >5.4
#/Traverse	102.00	42.00	28.00	24.00	18.00	14.00	10.00	2.40	0.20	240	70	
Overall %	42.8	17.5	10.8	10.0	7.8	6.5	4.2	1.0	0.1			
Cumulative %	42.8	60.1	71.0	81.0	88.8	94.7	98.8	99.8	100.0			
Starch #/T	0.00	0.00	0.00	2.00	0.00	3.00	3.00	0.80	0.00			
% (>5.4 um)				2.8	0.0	4.3	4.3	0.8	0.0			12.4
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.3	0.0			0.3
Grain Meal #/T	0.00	0.00	23.00	22.00	18.00	11.00	7.00	1.80	0.20			
% (>5.4 um)				31.8	27.3	16.8	10.1	2.3	0.3			87.4
Feed %(>8.4 um)				34.8	27.2	20.1	14.4	3.2	0.3			99.7

Respirable Fraction = 71.0 Percent

Table 98. VISIT K-5

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.8	>30.	TOTAL All	TOTAL >8.4	AVG % >5.4
#/Traverse	103.00	48.00	18.00	14.00	28.00	17.00	18.00	2.00	0.60	244	75	
Overall %	42.2	19.7	7.4	5.7	10.7	7.0	8.2	0.8	0.2			
Cumulative %	42.3	62.0	69.4	75.1	88.8	92.8	98.8	99.8	100.0			
Starch #/T	0.00	0.00	0.00	0.00	7.00	11.00	8.00	1.00	0.60			
% (>5.4 um)				0.0	8.4	14.7	10.7	1.3	0.8			37.0
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.0	0.0			0.0
Grain Meal #/T	0.00	0.00	18.00	14.00	18.00	8.00	7.00	1.00	0.00			
% (>5.4 um)				18.8	25.5	8.0	9.4	1.3	0.0			53.0
Feed %(>5.4 um)				18.8	34.8	22.8	20.1	2.7	0.8			100.0

Respirable Fraction = 69.4 Percent

Table 99. VISIT K-6

VARIABLE	SIZE CLASSES, MICRONS <2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-28.5	>30.	TOTAL All	TOTAL >5.4	AVG % >8.4
#/Traverse	105.00	35.00	34.00	35.00	26.00	10.50	2.50	1.38	0.80	258	75	
Overall %	40.8	17.4	13.1	13.5	9.7	4.1	1.0	0.8	0.2			
Cumulative %	40.8	57.8	71.1	84.8	94.3	98.3	99.3	99.8	100.0			
Starch #/T	0.00	0.00	0.00	1.00	4.00	2.00	0.75	0.50	0.00			
% (>5.4 um)				1.3	5.3	4.0	1.0	0.7	0.0			12.4
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13			
% (>8.4 um)				0.0	0.0	0.0	0.0	0.0	0.2			0.2
Grain Meal #/T	0.00	1.00	22.00	34.00	21.00	7.50	1.75	0.88	0.38			
% (>8.4 um)				48.4	28.0	10.0	2.3	1.2	0.8			87.8
Feed %(>8.4 um)				48.7	33.4	18.0	2.2	1.8	0.6			98.8

Respirable Fraction = 71.1 PERCENT

Table 100. VISIT K-7

	SIZE CLASSES, MICRONS											
VARIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL 411	TOTAL >5.4	AVG % >5.4
#/Traverse	101.00	33.00	12.00	8.50	8.00	6.00	1.25	0.50	0.18	172	28	
Overall %	58.8	19.1	7.0	5.5	5.2	3.5	0.7	0.3	0.1			
Cumulative %	58.8	77.7	84.7	90.2	95.4	98.9	99.6	99.8	100.0			
Starch #/T	0.00	0.00	0.00	2.00	1.00	2.00	0.38	0.08	0.00			
% (>5.4 um)				7.8	8.8	7.8	1.4	0.3	0.0			20.7
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.23	0.08			
% (>5.4 um)				0.0	0.0	0.0	0.5	0.8	0.2			1.5
Grain Meal #/T	0.00	0.00	11.00	7.80	7.50	4.00	0.75	0.14	0.14			
% (>5.4 um)				28.4	28.4	15.1	2.8	0.5	0.5			75.8
Feed %(>5.4 um)				85.9	32.2	22.7	4.3	0.8	0.8			88.5

Respirable Fraction = 84.7 Percent

Table 101. VISIT K-8

	SIZE CLASSES, MICRONS											
VARIABLE	<2.7	2.7-3.8	3.8-5.4	5.4-7.8	7.8-10.8	10.8-15.3	15.3-21.8	21.8-30.5	>30.	TOTAL A11	TOTAL >5.4	AVG % >5.4
#/Traverse	107.00	48.00	34.00	31.00	13.00	6.00	2.40	0.83	0.11	242	53	
Overall %	44.2	19.8	14.1	12.8	5.4	2.8	1.0	0.1	0.0			
Cumulative %	44.2	64.1	78.2	91.0	96.3	99.8	99.8	100.0	100.0			
Starch #/T	0.00	0.00	0.00	1.00	0.00	0.50	0.20	0.11	0.11			
% (>5.4 um)				1.8	0.0	0.8	0.4	0.2	0.2			3.8
Skin #/T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00			
% (>5.4 um)				0.0	0.0	0.0	0.0	0.2	0.0			0.2
Grain Meal #/T	0.00	3.00	33.00	30.00	13.00	5.50	2.20	0.11	0.00			
% (>5.4 um)				56.6	24.6	10.4	4.2	0.2	0.0			96.2
Feed %(>5.4 um)				88.7	24.6	11.4	4.5	0.4	0.2			88.8

Respirable Fraction = 78.2 Percent

FARM A

Table 102. ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE			SHAPE		
	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
VISIT 1	0	0	0	0	0	0
VISIT 2	7	0	19	14	3	0
VISIT 3	5	0	28	6	1	0
VISIT 4	2	0	28	5	0	0
VISIT 5	4	1	13	1	3	0
VISIT 6	2	0	2	9	0	0
VISIT 7	2	0	0	7	0	1
VISIT 8	2	0	45	19	3	0
TOTALS	24	1	135	61	10	1
FARM TOTAL =	232					

Table 102b. SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	9	0	0
1.68 - 2.1	0	0	7	18	2	0
2.1 - 3.36	0	0	17	13	4	0
3.36 - 4.2	1	0	22	6	2	1
4.2 - 6.72	3	0	36	5	2	0
6.72 - 8.4	9	0	20	5	0	0
8.4 - 10.3	5	0	13	3	0	0
10.3 - 20.0	3	0	12	2	0	0
> 20.0	3	1	8	0	0	0
TOTAL	24	1	135	61	10	1
% TOTAL	10	0	58	26	4	0
% FEED =	69					

FARM B

Table 103. ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE			SHAPE		
	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
VISIT 1	5	1	7	3	0	2
VISIT 2	0	0	0	0	0	0
VISIT 3	0	0	18	2	0	0
VISIT 4	3	0	30	3	1	1
VISIT 5	5	0	10	1	0	0
VISIT 6	4	0	10	3	0	1
VISIT 7	1	1	16	2	0	0
VISIT 8	2	1	13	5	2	0
TOTALS	20	3	104	19	3	4
FARM TOTAL =	153					

Table 103b. SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	0	0	0
1.68 - 2.1	0	0	1	6	2	1
2.1 - 3.36	0	0	18	10	1	0
3.36 - 4.2	4	0	11	3	0	2
4.2 - 6.72	7	0	28	0	0	0
6.72 - 8.4	1	0	20	0	0	1
8.4 - 10.3	2	0	10	0	0	0
10.3 - 20.0	5	1	8	0	0	0
> 20.0	1	1	8	0	0	0
TOTAL	20	2	104	19	3	4
% TOTAL	13	1	68	12	2	3
% FEED =	81					

FARM C

Table 104. ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE STARCH	TYPE SKIN	TYPE MEAL	SHAPE IRREG	SHAPE ROUND	SHAPE CYLND
VISIT 1	4	0	6	4	0	0
VISIT 2	8	0	12	4	1	0
VISIT 3	4	0	14	4	0	0
VISIT 4	3	0	10	0	0	0
VISIT 5	3	0	14	4	0	0
VISIT 6	2	1	7	4	0	0
VISIT 7	3	1	10	1	0	0
VISIT 8	2	0	14	2	0	0
TOTALS	29	2	87	23	1	0
FARM TOTAL =	142					

Table 104b. SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	5	0	0
1.68 - 2.1	1	0	0	11	1	0
2.1 - 3.36	0	0	10	5	0	0
3.36 - 4.2	1	0	5	0	0	0
4.2 - 6.72	5	0	18	2	0	0
6.72 - 8.4	12	0	15	0	0	0
8.4 - 10.3	4	0	9	0	0	0
10.3 - 20.0	3	1	22	0	0	0
> 20.0	3	1	8	0	0	0
TOTAL	29	2	87	23	1	0
% TOTAL	20	1	61	16	1	0
% FEED =	82					

FARM D

Table 105. ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE STARCH	TYPE SKIN	TYPE MEAL	SHAPE IRREG	SHAPE ROUND	SHAPE CYLND
VISIT 1	0	0	0	0	0	0
VISIT 2	2	1	6	2	0	0
VISIT 3	0	0	0	0	0	0
VISIT 4	3	0	15	1	1	0
VISIT 5	1	3	14	3	0	0
VISIT 6	4	0	14	3	0	0
VISIT 7	2	2	5	0	0	0
VISIT 8	3	0	25	0	0	0
TOTALS	15	6	79	9	1	0
FARM TOTAL =	110					

Table 105b. SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	0	0	0
1.68 - 2.1	0	0	2	2	0	0
2.1 - 3.36	0	0	6	5	1	0
3.36 - 4.2	0	0	9	2	0	0
4.2 - 6.72	3	0	22	0	0	0
6.72 - 8.4	5	0	14	0	0	0
8.4 - 10.3	1	0	6	0	0	0
10.3 - 20.0	3	2	10	0	0	0
> 20.0	3	4	10	0	0	0
TOTAL	15	6	79	9	1	0
% TOTAL	14	5	72	8	1	0
% FEED =	85					

Table 106. FARM E
ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE STARCH	TYPE SKIN	TYPE MEAL	SHAPE IRREG	SHAPE ROUND	SHAPE CYLND
VISIT 1	0	0	0	0	0	0
VISIT 2	0	0	0	0	0	0
VISIT 4	1	0	21	0	0	0
VISIT 5	3	0	23	5	0	0
VISIT 6	1	0	12	3	0	1
VISIT 7	1	0	14	3	1	0
VISIT 8	5	0	10	0	2	0
VISIT 9	2	0	23	6	1	0
TOTALS	13	0	103	17	4	1
FARM TOTAL =	138					

Table 106b. SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	1	0	0
1.68 - 2.1	0	0	5	7	1	0
2.1 - 3.36	0	0	10	4	3	0
3.36 - 4.2	2	0	9	4	0	1
4.2 - 6.72	2	0	21	1	0	0
6.72 - 8.4	1	0	15	0	0	0
8.4 - 10.3	3	0	17	0	0	0
10.3 - 20.0	2	0	15	0	0	0
> 20.0	3	0	11	0	0	0
TOTAL	13	0	103	17	4	1
% TOTAL	9	0	75	12	3	1
% FEED =	84					

Table 107. FARM F
ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE STARCH	TYPE SKIN	TYPE MEAL	SHAPE IRREG	SHAPE ROUND	SHAPE CYLND
VISIT 1	3	0	0	0	0	0
VISIT 2	0	0	9	0	1	0
VISIT 3	1	0	6	2	3	3
VISIT 4	2	0	7	1	1	0
VISIT 5	3	1	11	3	0	0
VISIT 6	3	0	24	11	0	1
VISIT 7	0	0	0	0	0	0
VISIT 8	13	0	13	1	0	0
TOTALS	25	1	70	18	5	4
FARM TOTAL =	123					

Table 107b. SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	3	0	0
1.68 - 2.1	0	0	0	5	1	0
2.1 - 3 36	1	0	10	1	4	1
3.36 - 4.2	3	0	13	2	0	0
4.2 - 6.72	7	1	15	5	0	0
6.72 - 8 4	6	0	8	2	0	0
8.4 - 10.3	3	0	11	0	0	2
10.3 - 20.0	4	0	8	0	0	1
> 20.0	1	0	5	0	0	0
TOTAL	25	1	70	18	5	4
% TOTAL	20	1	57	15	4	3
% FEED =	77					

Table 108. FARM G
ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE STARCH	TYPE SKIN	TYPE MEAL	SHAPE IRREG	SHAPE ROUND	SHAPE CYLND
VISIT 1	1	0	7	0	0	0
VISIT 2	0	0	0	0	0	0
VISIT 3	3	0	12	5	0	0
VISIT 4	4	0	9	2	0	0
VISIT 5	11	0	8	0	0	0
VISIT 6	5	0	19	2	0	0
VISIT 7	2	0	17	0	0	0
VISIT 8	5	0	11	2	0	0
TOTALS	31	0	83	11	0	0
FARM TOTAL =	125					

Table 108b. SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	1	0	0
1.68 - 2.1	0	0	1	2	0	0
2.1 - 3.36	1	0	7	5	0	0
3.36 - 4.2	0	0	9	3	0	0
4.2 - 6.72	12	0	24	0	0	0
6.72 - 8.4	6	0	16	0	0	0
8.4 - 10.3	5	0	6	0	0	0
10.3 - 20.0	2	0	15	0	0	0
> 20.0	5	0	5	0	0	0
TOTAL	31	0	83	11	0	0
% TOTAL	25	0	66	9	0	0
% FEED =	91					

Table 109. FARM H
ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE STARCH	TYPE SKIN	TYPE MEAL	SHAPE IRREG	SHAPE ROUND	SHAPE CYLND
VISIT 1	0	0	0	1	1	0
VISIT 2	0	0	3	1	0	0
VISIT 3	0	0	0	0	0	0
VISIT 4	0	0	11	0	1	2
VISIT 5	3	0	20	3	0	0
VISIT 6	3	1	6	0	0	0
VISIT 7	2	0	10	1	0	0
VISIT 8	2	0	9	3	1	0
TOTALS	10	1	59	9	3	2
FARM TOTAL =	84					

Table 109b. SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	1	0	0
1.68 - 2.1	0	0	3	3	1	0
2.1 - 3.36	0	0	4	0	1	0
3.36 - 4.2	0	0	5	4	1	0
4.2 - 6.72	1	0	21	1	0	1
6.72 - 8.4	5	0	10	0	0	1
8.4 - 10.3	2	0	9	0	0	0
10.3 - 20.0	2	0	4	0	0	0
> 20.0	0	1	3	0	0	0
TOTAL	10	1	59	9	3	2
% TOTAL	12	1	70	11	4	2
% FEED =	82					

Table 110. FARM I
ORIGIN ANO MORPHOLOGY BY FARM VISIT

VISIT #	TYPE STARCH	SKIN	MEAL	SHAPE IRREG	ROUND	CYLND
VISIT 1	3	0	16	7	5	1
VISIT 2	0	0	0	0	0	0
VISIT 4	1	0	10	6	2	1
VISIT 5	0	0	19	12	4	0
VISIT 6	2	0	25	2	1	2
VISIT 7	2	1	21	1	0	0
VISIT 8	0	0	4	1	0	0
VISIT 9	3	0	20	5	1	0
TOTALS	11	1	115	34	13	4
FARM TOTAL =	178					

Table 110b. SIZE OISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	3	0	0
1.68 - 2.1	0	0	5	11	4	2
2.1 - 3.36	1	0	22	11	8	2
3.36 - 4.2	1	0	18	6	1	0
4.2 - 6.72	5	0	27	3	0	0
6.72 - 8.4	3	0	11	0	0	0
8.4 - 10.3	1	0	14	0	0	0
10.3 - 20.0	0	0	11	0	0	0
> 20.0	0	1	7	0	0	0
TOTAL	11	1	115	34	13	4
% TOTAL	6	1	65	19	7	2
% FEEO =	71					

Table 111. FARM J
ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE STARCH	SKIN	MEAL	SHAPE IRREG	ROUNO	CYLNO
VISIT 1	3	0	3	0	1	0
VISIT 2	1	0	8	1	3	0
VISIT 4	3	0	6	1	0	1
VISIT 5	6	0	17	6	5	0
VISIT 6	0	0	0	0	0	0
VISIT 7	0	0	0	0	0	0
VISIT 8	0	2	0	5	1	1
VISIT 9	3	0	13	11	1	0
TOTALS	16	2	47	24	11	2
FARM TOTAL =	102					

Table 111b. SIZE OISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUNO	CYLNO
< 1.68	0	0	0	0	0	0
1.68 - 2.1	0	0	0	7	1	0
2.1 - 3.36	0	0	2	6	6	0
3.36 - 4.2	1	0	6	3	3	0
4.2 - 6.72	4	0	17	3	1	1
6.72 - 8.4	2	0	7	0	0	0
8.4 - 10.3	2	0	6	1	0	1
10.3 - 20.0	3	1	4	3	0	0
> 20.0	4	1	5	1	0	0
TOTAL	16	2	47	24	11	2
% TOTAL	16	2	46	24	11	2
% FEEO =	62					

Table 112. FARM K
ORIGIN AND MORPHOLOGY BY FARM VISIT

VISIT #	TYPE			SHAPE		
	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
VISIT 1	2	0	9	2	0	0
VISIT 2	1	0	13	2	0	0
VISIT 4	1	0	9	0	0	0
VISIT 5	3	0	25	4	0	0
VISIT 6	4	0	10	0	0	0
VISIT 7	0	0	0	0	0	0
VISIT 8	0	0	22	3	1	0
VISIT 9	1	0	18	1	1	0
TOTALS	12	0	106	12	2	0
FARM TOTAL =	132					

Table 112b. SIZE DISTRIBUTION FOR ALL VISITS

SIZE MICRONS	STARCH	SKIN	MEAL	IRREG	ROUND	CYLND
< 1.68	0	0	0	0	0	0
1.68 - 2.1	0	0	0	4	1	0
2.1 - 3.36	0	0	12	6	1	0
3.36 - 4.2	0	0	24	1	0	0
4.2 - 6.72	3	0	23	1	0	0
6 72 - 8.4	4	0	10	0	0	0
8.4 - 10.3	2	0	13	0	0	0
10.3 - 20.0	2	0	14	0	0	0
> 20.0	1	0	10	0	0	0
TOTAL	12	0	106	12	2	0
% TOTAL	9	0	80	9	2	0
% FEED =	89					

Acknowledgements

The author wishes to thank Dr. A. J. Heber, Major Professor, under whose valuable guidance this experiment and work was carried out. His help, patience, continued encouragement and constructive criticism during the entire period of graduate study and preparation of this report is much appreciated. The author thanks the other members of her committee: Dr. J. Ernest Minton and Dr. Charles Spillman and Dr. John Slocombe for their assistance and review of this report.

The author also wishes to thank the National Pork Producers Council and the Kansas Agricultural Experiment Station which provided the funds that made this project possible.

Special thanks are also due to Dr. Jon Faubian, Grain Science, who provided assistance in feed particle identification, and Leneil Harbers, Animal Science, for assistance in identifying starch and use of equipment, Lloyd Willard, Veterinary Medicine, for his untiring patience and help with the SEM work, and Dr. Alberto Broce, Entomology. for his help and use of equipment.

Appreciation and thanks also are due to Christy Anderson, Agricultural Engineering, for her work in typing and editing this report.

A QUANTITATIVE AND QUALITATIVE ANALYSIS OF SWINE FINISHING HOUSE DUST WITH SCANNING ELECTRON AND LIGHT MICROSCOPY

by

MARCELLA STROIK

B.S., University of Wisconsin at River Falls, 1983

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

AGRICULTURAL MECHANIZATION

Department of Agricultural Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1987

Samples of aerial dust and other pertinent data were collected from 11 commercial swine finishing units. The sampling was conducted over an eight month period from July, 1985 to February, 1986. Each farm was sampled approximately once a month. Dust particles were collected on membrane filters with a low-volume air sampler. Both light microscopy (LM) and the Scanning Electron Microscopy (SEM) were utilized to evaluate the swine dust particles. The LM was fitted with a Porton reticule disc for particle sizing and counting. The polarizer in the LM was used to positively identify starch particles. Other particles such as grain meal and skin were also identified with the LM. The SEM was used to supplement identification of particles smaller than 5.4 microns. Shape and texture were the primary identification tools.

Analysis by both LM and SEM revealed the airborne particles to be diverse in both shape and size. Particles identified include grain meal, starch, skin, pollen and insect parts. The feed component (starch and grain meal) was 79 percent by both SEM analysis and LM analysis (over 16,000 particles were counted in the LM analysis). Thus, feed particles made up the greatest percentage of the swine finishing house airborne particles.